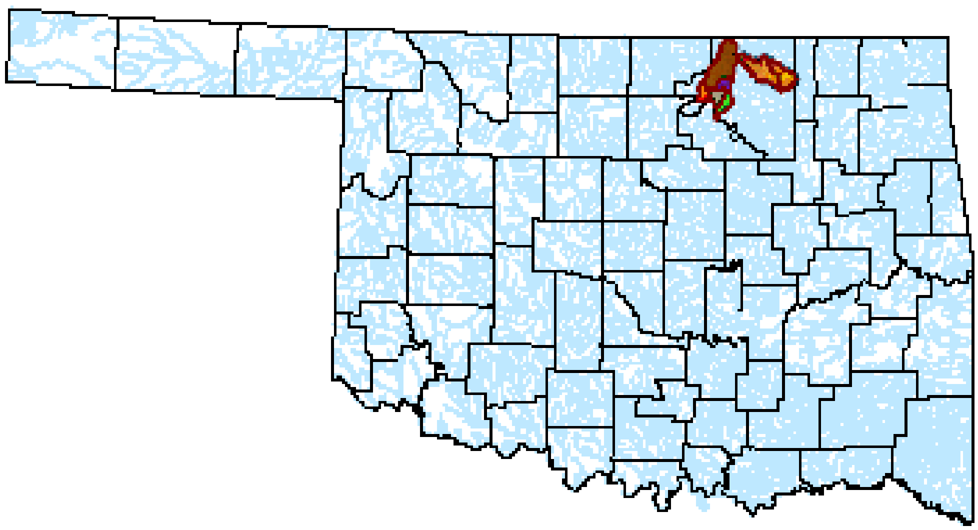
FINAL

BACTERIA TOTAL MAXIMUM DAILY LOADS FOR STREAMS IN SALT CREEK AREA, OKLAHOMA



Prepared By:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

AUGUST 31, 2009

FINAL

BACTERIA TOTAL MAXIMUM DAILY LOADS FOR STREAMS IN SALT CREEK AREA, OKLAHOMA

OKWBID

OK621200040010_00 - Salt Creek

OK621200040010_10 - Salt Creek

OK621200040070_00 - Little Chief Creek

OK621200010400_00 - Gray Horse Creek

OK621200020020_00 - Doga Creek

OK121400040010_00 - Sand Creek

Prepared by:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

AUGUST 31, 2009

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ASAE	American Society of Agricultural Engineers
BMP	best management practice
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cfu	Colony-forming unit
CPP	Continuing planning process
CWA	Clean Water Act
DMR	Discharge monitoring report
LA	Load allocation
LDC	Load duration curve
mg	Million gallons
mgd	Million gallons per day
mL	Milliliter
MOS	Margin of safety
MS4	Municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
O.S.	Oklahoma statutes
ODAFF	Oklahoma Department of Agriculture, Food and Forestry
ODEQ	Oklahoma Department of Environmental Quality
OPDES	Oklahoma Pollutant Discharge Elimination System
OSWD	Onsite wastewater disposal
OWRB	Oklahoma Water Resources Board
PBCR	Primary body contact recreation
PRG	Percent reduction goal
SSO	Sanitary sewer overflow
TMDL	Total maximum daily load
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WLA	Wasteload allocation
WQM	Water quality monitoring
WQS	Water quality standard
WWTP	Wastewater treatment plant

Executive Summary

This report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria fecal coliform, *Escherichia coli (E. coli),* or Enterococci for certain waterbodies in the Salt Creek and Sand Creek area. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that a receiving water is contaminated with human or animal feces and that there is a potential health risk for individuals exposed to the water. Data assessment and TMDL calculations are conducted in accordance with requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR Part 130), USEPA guidance, and Oklahoma Department of Environmental Quality (ODEQ) guidance and procedures. ODEQ is required to submit all TMDLs to USEPA for review and approval. Once the USEPA approves a TMDL, then the waterbody may be moved to Category 4a of a state's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (USEPA 2003).

The purpose of this report is to establish pollutant load allocations for indicator bacteria in impaired waterbodies, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding the WQS for that pollutant. A TMDL consists of a wasteload allocation (WLA), load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources, and includes stormwater discharges regulated under the National Pollutant Discharge Elimination System (NPDES) as point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL set aside to account for the uncertainty associated with natural process in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce bacteria loadings within each watershed. Watershed-specific control actions and management measures will be identified, selected, and implemented under a separate process.

E.1 Problem Identification and Water Quality Target

A decision was made to place specific waterbodies in this Study Area, listed in Table ES-1, on the ODEQ 2008 303(d) list because evidence of nonsupport of primary body contact recreation (PBCR) was observed.

Elevated levels of bacteria above the WQS for one or more of the bacterial indicators result in the requirement that a TMDL be developed. The TMDLs established in this report are a necessary step in the process to develop the bacteria loading controls needed to restore the primary body contact recreation use designated for each waterbody.

Table ES-1 Excerpt from the 2008 Integrated Report – Comprehensive Waterbody Assessment Category List

Waterbody ID	Waterbody Name	Stream Miles	Category	TMDL Date	Primary Body Contact Recreation
OK621200040010_00	Salt Creek	17	5	2013	N
OK621200040010_10	Salt Creek	44	5	2013	N
OK621200040070_00	Little Chief Creek	13	5	2013	N
OK621200010400_00	Gray Horse Creek	16	5	2019	N
OK621200020020_00	Doga Creek	10	5	2016	N
OK121400040010_00	Sand Creek	60	5	2019	N

N = Not Supporting; Source: 2008 Integrated Report, ODEQ 2008

For the data collected between 1999 and 2007, when there is enough data to make an assessment, evidence of nonsupport of primary body contact recreation beneficial uses was observed for all three bacteria indicators in Sand Creek, Gray Horse Creek and Doga Creek. Nonsupport of PBCR was observed for Enterococci in both segments of Salt Creek (OK621200040010_00 & OK621200040010_10). There is not enough data in Little Chief Creek to assess the PBCR uses for Enterococci and E. Coli. Little Chief Creek was found to support PBCR beneficial uses for Fecal Coliform

Table ES-2 summarizes the waterbodies requiring TMDLs for not supporting PBCR.

Table ES-2 Waterbodies Requiring TMDLs for Not Supporting Primary Body Contact Recreation Use as a Result of Re-assessment

WQM Station	Waterbody ID	Waterbody Name	Indicator Bacteria		
			FC	ENT	*EC*
OK621200-04-0010F	OK621200040010_00	Salt Creek		**X**	
OK621200-04-0010J OK621200-04-0010P	OK621200040010_10	Salt Creek		**X**	
OK621200-04-0070C	OK621200040070_00	Little Chief Creek			
OK621200-01-0400C OK621200-01-0400T	OK621200010400_00	Gray Horse Creek	**X**	**X**	**X**
OK621200-02-0020C OK621200-02-0020M	OK621200020020_00	Doga Creek	**X**	**X**	**X**
OK121400-04-0010F OK121400-04-0010T	OK121400040010_00	Sand Creek	**X**	**X**	**X**

The definition of PBCR is summarized by the following excerpt from Chapter 45 of the Oklahoma WQSs.

(a) Primary Body Contact Recreation involves direct body contact with the water where a possibility of ingestion exists. In these cases the water shall not contain chemical, physical or biological substances in concentrations that are irritating to skin or sense organs or are toxic or cause illness upon ingestion by human beings.

(b) In waters designated for Primary Body Contact Recreation...limits...shall apply only during the recreation period of May 1 to September 30. The criteria for Secondary Body Contact Recreation will apply during the remainder of the year.

To implement Oklahoma's WQS for PBCR, OWRB promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2007). The excerpt below from Chapter 46: 785:46-15-6, stipulates how water quality data will be assessed to determine support of the PBCR use as well as how the water quality target for TMDLs will be defined for each bacterial indicator.

(a) Scope. The provisions of this Section shall be used to determine whether the subcategory of Primary Body Contact of the beneficial use of Recreation designated in OAC 785:45 for a waterbody is supported during the recreation season from May 1 through September 30 each year. Where data exist for multiple bacterial indicators on the same waterbody or waterbody segment, the determination of use support shall be based upon the use and application of all applicable tests and data.

(b) Screening levels.

(1) The screening level for fecal coliform shall be a density of 400 colonies per 100ml.

(2) The screening level for Escherichia coli shall be a density of 235 colonies per 100 ml in streams designated in OAC 785:45 as Scenic Rivers and in lakes, and 406 colonies per 100 ml in all other waters of the state designated as Primary Body Contact Recreation.

(3) The screening level for enterococci shall be a density of 61 colonies per 100 ml in streams designated in OAC 785:45 as Scenic Rivers and in lakes, and 108 colonies per 100 ml in all other waters of the state designated as Primary Body Contact Recreation.

(c) Fecal coliform:

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to fecal coliform if the geometric mean of 400 colonies per 100 ml is met and no greater than 25% of the sample concentrations from that waterbody exceed the screening level prescribed in (b) of this Section.

(2) The parameter of fecal coliform is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

(3) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to fecal coliform if the geometric mean of 400 colonies per 100 ml is not met, or greater than 25% of the sample concentrations from that

waterbody exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

(d) Escherichia coli (E. coli):

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is met, or the sample concentrations from that waterbody taken during the recreation season do not exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

(2) The parameter of E. coli is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

(3) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is not met and any of the sample concentrations from that waterbody taken during the recreation season exceed a screening level prescribed in (b) of this Section.

(e) Enterococci:

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to enterococci if the geometric mean of 33 colonies per 100 ml is met, or the sample concentrations from that waterbody taken during the recreation season do not exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

(2) The parameter of enterococci is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

(3) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to enterococci if the geometric mean of 33 colonies per 100 ml is not met and any of the sample concentrations from that waterbody taken during the recreation season exceed a screening level prescribed in (b) of this Section.

Compliance with the Oklahoma WQS is based on meeting requirements for all three bacterial indicators. Where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, each indicator group must demonstrate compliance with the numeric criteria prescribed (OWRB 2006).

As stipulated in the WQS, utilization of the geometric mean to determine compliance for any of the three indicator bacteria depends on the collection of five samples within a 30-day period. For most waterbodies in Oklahoma there are insufficient data available to calculate the 30-day geometric mean since most water quality samples are collected once a month. As a result, waterbodies placed on the 303(d) list for not supporting the PBCR are the result of individual samples exceeding the instantaneous criteria or the long-term geometric mean of individual samples exceeding the geometric mean criteria for each respective bacterial indicator. Targeting the instantaneous criterion established for the primary body contact recreation season (May 1st to September 30th) as the water quality goal for TMDLs corresponds to the basis for 303(d) listing and may be protective of the geometric mean criterion as well as the criteria for the secondary contact recreation season. However, both the instantaneous and geometric mean criteria for *E. coli* and Enterococci will be evaluated as water quality targets to ensure the most protective goal is established for each waterbody.

All TMDLs for fecal coliform must take into account that no more than 25 percent of the samples may exceed the instantaneous numeric criteria. For *E. coli* and Enterococci, no samples may exceed instantaneous criteria. Since the attainability of stream beneficial uses for *E. coli* and Enterococci is based on the compliance of either the instantaneous or a long-term geometric mean criterion, percent reductions goals will be calculated for both criteria. TMDLs will be based on the percent reduction required to meet either the instantaneous or the long-term geometric mean criterion, whichever is less.

E.2 Pollutant Source Assessment

There are no NPDES permitted facilities of any type in the contributing watershed of Little Chief Creek, Gray Horse Creek, Doga Creek and Sand Creek. There are two continuous point discharges in Salt Creek segments (OK621200040010_00 & OK621200040010_00). Only eight (8) SSO occurrences were reported in the Study Area between October 1991 and January 2007. NPDES-permitted facilities operating in the Study Area are relatively minor and for the most part tend to meet instream water quality criteria in their effluent. Thus, nonpoint sources are considered to be the major source of bacteria loading in each watershed.

Nonpoint source bacteria loading to the receiving streams of each waterbody may emanate from a number of different sources including wildlife, various agricultural activities and domesticated animals, land application fields, urban runoff, failing onsite wastewater disposal (OSWD) systems, and domestic pets. The data analysis and the load duration curves (LDC) demonstrate that exceedances in stream segments are the result of a variety of nonpoint source loading occurring during a range of flow conditions. Low flow exceedances are likely due to a combination of non-point sources, uncontrolled point sources and permit noncompliance.

E.3 Using Load Duration curves to Develop TMDLs

The TMDL calculations presented in this report are derived from LDCs. LDCs facilitate rapid development of TMDLs and as a TMDL development tool, may assist in identifying whether impairments are associated with point or nonpoint sources.

Use of the LDC obviates the need to determine a design storm or selected flow recurrence interval with which to characterize the appropriate flow level for the assessment of critical conditions. For waterbodies impacted by both point and nonpoint sources, the “nonpoint source critical condition” would typically occur during high flows, when rainfall runoff would contribute the bulk of the pollutant load, while the “point source critical condition” would typically occur during low flows, when treatment plant effluents would dominate the base flow of the impaired water. However, flow range is only a general indicator of the relative proportion of point/nonpoint contributions. It is not used in this report to quantify point source or nonpoint source contributions. Violations that occur during low flows may not be caused exclusively by point sources. Violations have been noted in some watersheds that contain no point sources. Research has show that bacteria loading in streams during low flow conditions may be due to direct deposit of cattle manure into streams and faulty septic tank/lateral field systems.

The basic steps to generating an LDC involve:

- obtaining daily flow data for the site of interest from the USGS;
- sorting the flow data and calculating flow exceedance percentiles for the time period and season of interest;
- obtaining the water quality data from the primary body contact recreation season (May 1 through September 30);
- matching the water quality observations with the flow data from the same date;
- display a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQS for each respective indicator;
- multiplying the flow by the water quality parameter concentration to calculate daily loads; then
- plotting the flow exceedance percentiles and daily load observations in a load duration plot.

LDCs display the maximum allowable load over the complete range of flow conditions by a line using the calculation of flow multiplied by the water quality criterion. The TMDL can be expressed as a continuous function of flow, equal to the line, or as a discrete value derived from a specific flow condition.

E.4 TMDL Calculations

As indicated above, the bacteria TMDLs for the 303(d)-listed waterbodies covered in this report were derived using LDCs. A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for uncertainty concerning the relationship between effluent limitations and water quality.

This definition can be expressed by the following equation:

$$TMDL = \Sigma\ WLA + \Sigma\ LA + MOS$$

For each waterbody the TMDLs presented in this report are expressed as a percent reduction across the full range of flow conditions (See Table ES-3). The difference between existing loading and the water quality target is used to calculate the loading reductions required.

Table ES-3 presents the percent reductions necessary for each bacterial indicator causing nonsupport of the PBCR use in each waterbody of the Study Area. Selection of the appropriate PRG for each bacteria indicator for each waterbody in Table ES-3 is denoted by the bold text. For Fecal Coliform, the PRG is determined based on instantaneous criteria. For *E. coli* and Enterococci, the TMDL PRG will be the lesser of that required to meet the geometric mean or instantaneous criteria because WQ standards are considered to be met if 1) either the geometric mean of all data is less than the geometric mean criteria, or 2) no samples exceed the instantaneous criteria.

Table ES-3 TMDL Percent Reduction Goals Required to Meet Water Quality Standards for Impaired Waterbodies

WQM Station	Waterbody ID	Waterbody Name	Percent Reduction Required				
			FC	EC		ENT	
			Instant-aneous	Instant-aneous	Geo-mean	Instant-aneous	Geo-mean
OK621200-04-0010F	OK621200040010_00	Salt Creek				97%	**67%**
OK621200-04-0010J OK621200-04-0010P	OK621200040010_10	Salt Creek				97%	**79%**
OK621200-01-0400C OK621200-01-0400T	OK621200010400_00	Gray Horse Creek	**81%**	84%	**38%**	93%	**76%**
OK621200-02-0020C OK621200-02-0020M	OK621200020020_00	Doga Creek	**61%**	78%	**48%**	87%	**76%**
OK121400-04-0010F OK121400-04-0010T	OK121400040010_00	Sand Creek	**41%**	97%	**12%**	99%	**80%**

The TMDL, WLA, LA, and MOS vary with flow condition, and are calculated at every 5th flow interval percentile. For illustrative purposes, the TMDL, WLA, LA, and MOS are calculated for the median flow at each site in Table ES-4. The WLA component of each TMDL is the sum of all WLAs within the contributing watershed of each waterbody. The sum of the WLAs can be represented as a single line below the LDC. The LDC and the simple equation of:

$$\textit{Average LA} = \textit{average TMDL} - \textit{MOS} - \sum \textit{WLA}$$

can provide an individual value for the LA in counts per day which represents the area under the TMDL target line and above the WLA line. There are no permitted MS4s in the study area. Where there are no continuous point sources the WLA is zero.

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs include a MOS. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the uncertainty associated with calculating the allowable pollutant loading to ensure WQSs are attained. USEPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for uncertainty, then the MOS is considered explicit.

For the explicit MOS the water quality target was set at 10 percent lower than the water quality criterion for each pathogen which equates to 360 cfu/100 mL, 365.4 cfu/100 mL, and 97.2/100 mL for fecal coliform, *E. coli*, and Enterococci, respectively. The net effect of the TMDL with MOS is that the assimilative capacity or allowable pollutant loading of each waterbody is slightly reduced. These TMDLs incorporate an explicit MOS by using a curve representing 90 percent of the TMDL as the average MOS. The MOS at any given percent flow exceedance, therefore, can be defined as the difference in loading between the TMDL and the TMDL with MOS. The use of instream bacteria concentrations to estimate existing loading is another conservative element utilized in these TMDLs that can be recognized as an implicit MOS. This conservative approach to establishing the MOS will ensure that both the 30-day geometric mean and instantaneous bacteria standards can be achieved and maintained.

Table ES-4 TMDL Summaries Examples

Waterbody ID	Waterbody Name	Indicator Bacteria Species	TMDL† (cfu/day)	WLA† (cfu/day)	LA† (cfu/day)	MOS† (cfu/day)
OK621200040010_00	Salt Creek	ENT	2.75E+10	2.57E+08	2.45E+10	2.75E+09
OK621200040010_10	Salt Creek	ENT	1.92E+10	1.50E+08	1.71E+10	1.92E+09
OK621200010400_00	Gray Horse Creek	FC	1.74E+10	0	1.57E+10	1.74E+09
OK621200020020_00	Doga Creek	FC	1.26E+10	0	1.14E+10	1.26E+09
OK121400040010_00	Sand Creek	ENT	2.35E+10	0	2.12E+10	2.35E+09

† Derived for illustrative purposes at the median flow value

E.5 Reasonable Assurance

As authorized by Section 402 of the CWA, ODEQ has delegation of the NPDES in Oklahoma, except for certain jurisdictional areas related to agriculture and the oil and gas industry retained by the Oklahoma Department of Agriculture and Oklahoma Corporation Commission, for which the USEPA has retained permitting authority. The NPDES program in Oklahoma is implemented via Title 252, Chapter 606 of the Oklahoma Pollutant Discharge Elimination System (OPDES) Act, and in accordance with the agreement between ODEQ and USEPA relating to administration and enforcement of the delegated NPDES program. Implementation of WLAs for point sources is done through permits issued under the OPDES program.

SECTION 1
INTRODUCTION

1.1 TMDL Program Background

Section 303(d) of the Clean Water Act (CWA) and U.S. Environmental Protection Agency (USEPA) Water Quality Planning and Management Regulations (40 Code of Federal Regulations [CFR] Part 130) require states to develop total maximum daily loads (TMDL) for waterbodies not meeting designated uses where technology-based controls are in place. TMDLs establish the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so states can implement water quality-based controls to reduce pollution from point and nonpoint sources and restore and maintain water quality (USEPA 1991).

This report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria fecal coliform, *Escherichia coli (E. coli)*, or Enterococci for certain waterbodies in the Salt Creek and Sand Creek Area of the Arkansas River Basin. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that a receiving water is contaminated with human or animal feces and that there is a potential health risk for individuals exposed to the water. Data assessment and TMDL calculations are conducted in accordance with requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR Part 130), USEPA guidance, and Oklahoma Department of Environmental Quality (ODEQ) guidance and procedures. ODEQ is required to submit all TMDLs to USEPA for review and approval. Once the USEPA approves a TMDL, then the waterbody may be moved to Category 4a of a state's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (USEPA 2003).

The purpose of this TMDL report is to establish pollutant load allocations for indicator bacteria in impaired waterbodies, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding the WQS for that pollutant. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a waterbody based on the relationship between pollutant sources and in-stream water quality conditions. A TMDL consists of a wasteload allocation (WLA), load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources, and includes stormwater discharges regulated under the National Pollutant Discharge Elimination System (NPDES) as point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL set aside to account for the uncertainty associated with natural process in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce bacteria loadings within each watershed. Watershed-specific control actions and management measures will be identified, selected, and implemented under a separate process involving stakeholders who live and work in the watersheds, tribes, and local, state, and federal government agencies.

This TMDL report focuses on waterbodies that ODEQ placed in Category 5 of the 2008 Integrated Report [303(d) list] for nonsupport of primary body contact recreation (PBCR):

- Salt Creek (OK621200040010_00)
- Salt Creek (OK621200040010_10)
- Little Chief Creek (OK621200040070_00)
- Gray Horse Creek (OK621200010400_00)
- Doga Creek (OK621200020020_00)
- Sand Creek (OK121400040010_00)

Figure 1-1 is a location map showing the impaired segments of these waterbodies and their contributing watersheds. This map also displays the locations of the water quality monitoring (WQM) stations used as the basis for placement of these waterbodies on the Oklahoma 303(d) list. These waterbodies and their surrounding watersheds are hereinafter referred to as the Study Area.

Elevated levels of bacteria above the WQS also result in the requirement that a TMDL be developed. The TMDLs established in this report are a necessary step in the process to develop the bacteria loading controls needed to restore the contact recreation use designated for each waterbody. Table 1-1 provides a description of the locations of the WQM stations on the 303(d)-listed waterbodies.

Table 1-1 Water Quality Monitoring Stations used for 2008 303(d) Listing Decision

Waterbody Name	Waterbody ID	WQM Station	WQM Station Locations Descriptions
Salt Creek	OK621200040010_00	OK621200-04-0010F	SW¼ Section 8-24N-6E
Salt Creek	OK621200040010_10	OK621200-04-0010J OK621200-04-0010P	NE¼ Section 8-26N-6E NE¼ Section 33-28N-6E
Little Chief Creek	OK621200040070_00	OK621200-04-0070C	NE¼ Section 18-25N-6E
Gray Horse Creek	OK621200010400_00	OK621200-01-0400C OK621200-01-0400T	NE¼ Section 8-23N-6E Sections 13/24 24N-6E
Doga Creek	OK621200020020_00	OK621200-04-0070C	Boundary of Section 36-35N-4E and Section 1-24N-4E
Sand Creek	OK121400040010_00	OK121400-04-0010F OK121400-04-0010T	E.B. Section 21-26N-12E SE¼ Section 3-27N-8E

1.2 Watershed Description

General. The watersheds in the Salt Creek Study Area in this TMDL are located in Northern Oklahoma. The vast majority of the drainage area for the waterbodies included in this report is located in Osage County. Only a very small portion (less than 1%) of drainage area is located in Kay County and Washington County.

All watersheds in the Salt Creek Study Area are in the Flint Hills and Northern Cross Timbers eco-region. Table 1-2, derived from the 2000 U.S. Census, demonstrates that the counties in which these watersheds are located are sparsely populated (U.S. Census Bureau 2000).

Table 1-2 County Population and Density

County Name	Population (2000 Census)	Area (square miles)	Population Density (per square mile)
Osage	44437	2304	19
Kay	48080	945	51
Washington	48996	424	116

Climate. Table 1-3 summarizes the average annual precipitation for each stream segment. Average annual precipitation values among the stream segments in this portion of Oklahoma range between 38.5 and 40.1 inches (Oklahoma Climate Survey 2005).

Table 1-3 Average Annual Precipitation by Stream Segment

Waterbody Name	Waterbody ID	Average Annual (Inches)
Salt Creek	OK621200040010_00	38.74
Salt Creek	OK621200040010_10	38.74
Little Chief Creek	OK621200040070_00	39.12
Gray Horse Creek	OK621200010400_00	39.24
Doga Creek	OK621200020020_00	38.48
Sand Creek	OK121400040010_00	40.05

Land Use. Table 1-4 summarizes the acreages and the corresponding percentages of the land use categories for the contributing watershed associated with each respective Oklahoma waterbody. The land use/land cover data were derived from the U.S. Geological Survey (USGS) 2001 National Land Cover Dataset (USGS 2007). The land use categories are displayed in Figure 1-2.

The dominant land use throughout all of the Study Area is grassland. The second most prevalent land use in all sub-watersheds, except for Sand Creek, is the combination of pasture/hay and grassland/herbaceous. The exception is Sand Creek where Deciduous Forest is the second most prevalent land use category.

Table 1-4 Land Use Summaries by Watershed

Landuse Category	Stream Segments					
	Salt Creek	Salt Creek	Little Chief Creek	Gray Horse Creek	Doga Creek	Sand Creek
Waterbody ID	OK621200040010_00	OK621200040010_10	OK621200040070_00	OK621200010400_00	OK621200020020_00	OK121400040010_00
Herbaceous Wetland	0.44%	0.44%	0.10%	0.01%	1.25%	0.00%
Woody Wetland	3.01%	3.01%	0.18%	0.00%	6.06%	0.00%
Cultivated	3.90%	3.90%	1.59%	3.32%	4.71%	0.64%
Pasture Hay	9.05%	9.05%	0.52%	0.95%	11.58%	11.28%
Grassland	74.18%	74.18%	89.41%	81.29%	60.67%	47.62%
Shrub	0.36%	0.36%	0.00%	0.00%	3.72%	0.00%
Mixed Forest	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Evergreen Forest	0.00%	0.00%	0.00%	0.03%	0.00%	0.18%
Deciduous Forest	2.29%	2.29%	1.45%	10.99%	7.62%	34.30%
Barren	0.01%	0.01%	0.00%	0.00%	0.00%	0.01%
Developed High Intensity	0.02%	0.02%	0.00%	0.00%	0.00%	0.05%
Developed Medium Intensity	0.04%	0.04%	0.02%	0.00%	0.01%	0.12%
Developed Low Intensity	0.37%	0.37%	0.48%	0.04%	0.02%	0.45%
Developed Open Space	5.47%	5.47%	6.04%	3.10%	3.59%	5.03%
Water	0.99%	0.99%	0.16%	0.26%	0.77%	0.32%
Total Percentage:	100%	100%	100%	100%	100%	100%
Herbaceous Wetland (Acres)	141	577	24	2	293	0
Woody Wetland (Acres)	964	3,931	44	0	1,415	0
Cultivated (Acres)	1,251	5,105	385	1,052	1,101	992
Pasture Hay (Acres)	2,902	11,841	126	301	2,704	17,468
Grassland (Acres)	23,782	97,024	21,619	25,734	14,168	73,722
Shrub (Acres)	115	470	0	0	868	2
Mixed Forest	0	0	0	0	0	0
Evergreen Forest (Acres)	0	0	0	11	0	280
Deciduous Forest (Acres)	735	3,000	352	3,480	1,779	53,102
Barren (Acres)	2	9	0	0	0	8

Landuse Category	Stream Segments					
	Salt Creek	Salt Creek	Little Chief Creek	Gray Horse Creek	Doga Creek	Sand Creek
Waterbody ID	OK621200040010_00	OK621200040010_10	OK621200040070_00	OK621200010400_00	OK621200020020_00	OK121400040010_00
Developed High Intensity (Acres)	5	22	0	0	0	75
Developed Medium Intensity (Acres)	14	58	6	2	2	179
Developed Low Intensity (Acres)	120	489	115	13	4	697
Developed Open Space (Acres)	1,752	7,149	1,461	982	838	7,782
Water (Acres)	316	1,291	39	82	179	499
Total (Acres)	32,060	130,796	24,179	31,658	23,354	154,800

Figure 1-1 Watersheds Not Supporting Primary Body Contact Recreation Use within the Study Area

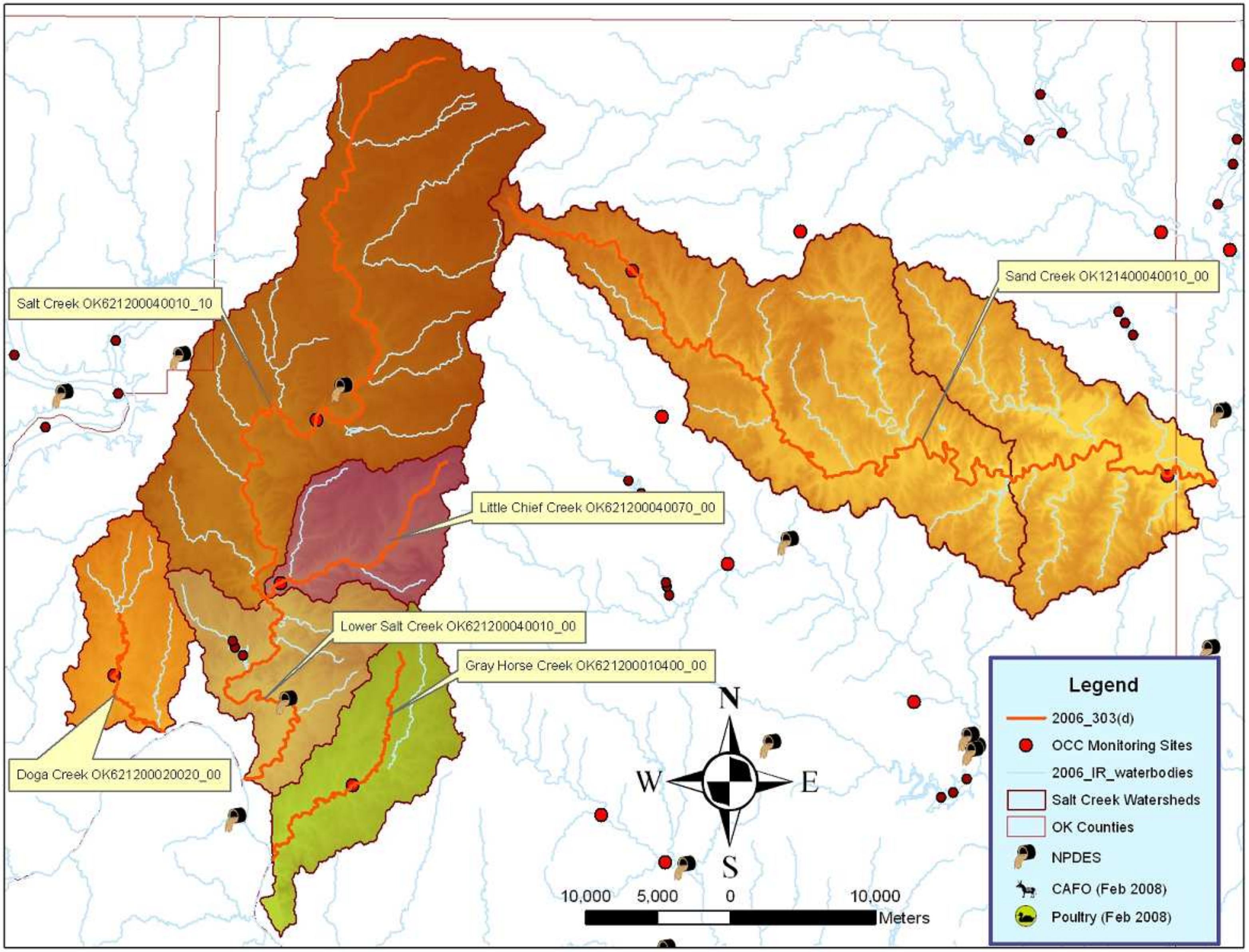
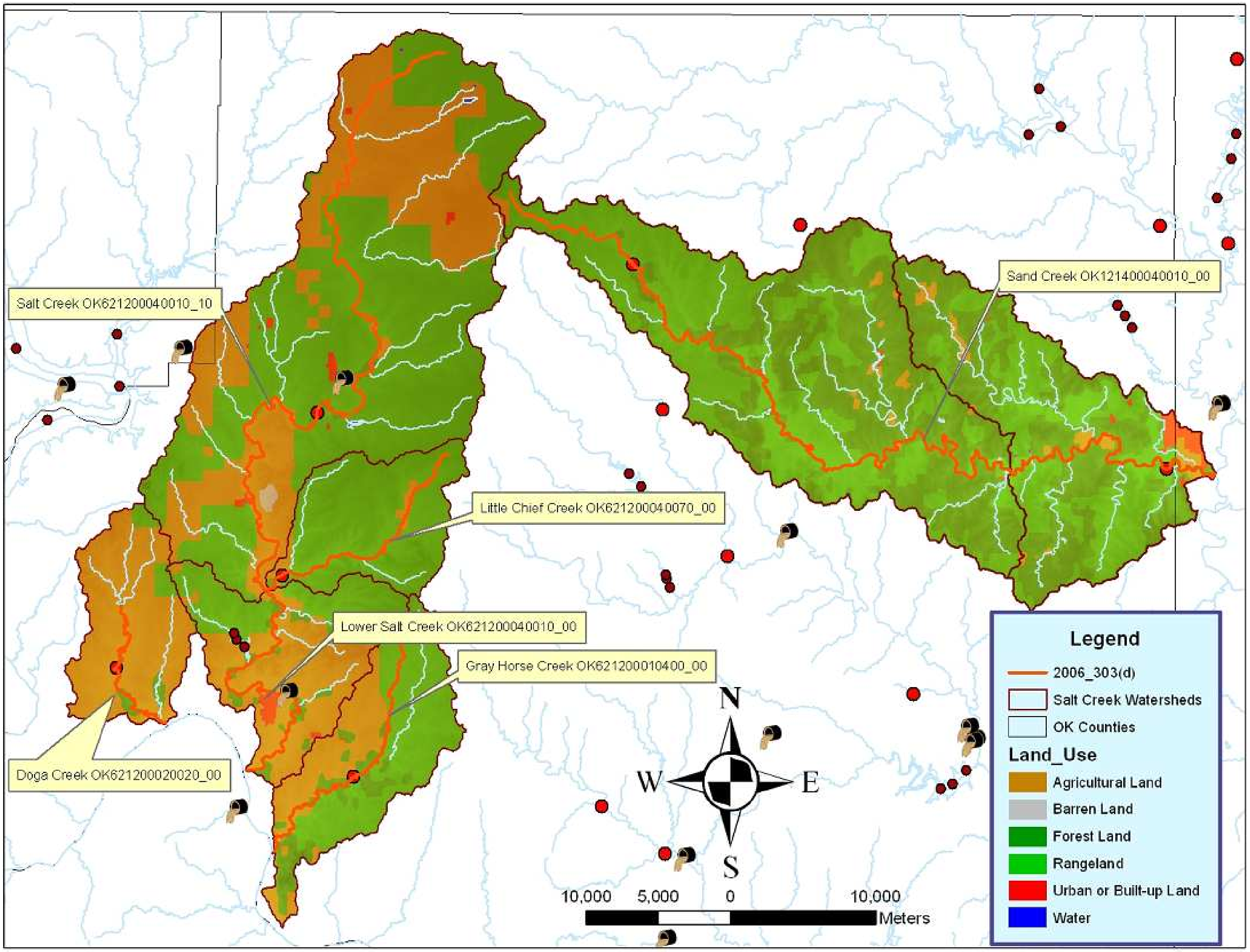


Figure 1-2 Land Use Map by Watershed



SECTION 2
PROBLEM IDENTIFICATION AND WATER QUALITY TARGET

2.1 Oklahoma Water Quality Standards

Title 785 of the Oklahoma Administrative Code includes Oklahoma's water quality standards (OWRB 2006). The OWRB has statutory authority and responsibility concerning establishment of state water quality standards, as provided under 82 Oklahoma Statute [O.S.], §1085.30. This statute authorizes the OWRB to promulgate rules …*which establish classifications of uses of waters of the state, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters.* [O.S. 82:1085:30(A)]. Beneficial uses are designated for all waters of the state. Such uses are protected through restrictions imposed by the antidegradation policy statement, narrative water quality criteria, and numerical criteria (OWRB 2006). The beneficial uses designated for Salt Creek (OK621200040010_00 & OK621200040010_10), Gray Horse Creek (OK621200010400_00), Doga Creek (OK621200020020_00), Little Chief Creek (OK621200040070_00), and Sand Creek (OK121400040010_00) include PBCR, public/private water supply, warm water aquatic community, industrial and municipal process and cooling water, agricultural water supply, public and private water supply, fish consumption, and aesthetics. The TMDLs in this report only address the PBCR-designated use. Table 2-1, an excerpt from Appendix B and Appendix C of the 2008 Integrated Report (ODEQ 2008), summarizes the PBCR use attainment status for the waterbodies of the Study Area and targeted TMDL date. The TMDL date for a stream segment indicates the priority of the stream segment for which a TMDL needs to be developed. The TMDLs established in this report are a necessary step in the process to restore the PBCR use designation for each waterbody.

Table 2-1 Excerpt from the Oklahoma 2008 303(d) List

Waterbody ID	Waterbody Name	Stream Miles	Category	TMDL Date	Primary Body Contact Recreation
OK621200040010_00	Salt Creek	17	5	2013	N
OK621200040010_10	Salt Creek	44	5	2013	N
OK621200040070_00	Little Chief Creek	13	5	2013	N
OK621200010400_00	Gray Horse Creek	16	5	2019	N
OK621200020020_00	Doga Creek	10	5	2016	N
OK121400040010_00	Sand Creek	60	5	2019	N

N = Not Supporting; Source: 2008 Integrated Report, ODEQ 2008

The definition of PBCR is summarized by the following excerpt from Chapter 45 of the Oklahoma WQS.

(a) Primary Body Contact Recreation involves direct body contact with the water where a possibility of ingestion exists. In these cases the water shall not contain chemical, physical or biological substances in concentrations that are irritating to skin or sense organs or are toxic or cause illness upon ingestion by human beings.

(b) In waters designated for Primary Body Contact Recreation...limits...shall apply only during the recreation period of May 1 to September 30. The criteria for Secondary Body Contact Recreation will apply during the remainder of the year.

To implement Oklahoma's WQS for PBCR, OWRB promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2007). The excerpt below from Chapter 46: 785:46-15-6, stipulates how water quality data will be assessed to determine support of the PBCR use as well as how the water quality target for TMDLs will be defined for each bacterial indicator.

(a) Scope. The provisions of this Section shall be used to determine whether the subcategory of Primary Body Contact of the beneficial use of Recreation designated in OAC 785:45 for a waterbody is supported during the recreation season from May 1 through September 30 each year. Where data exist for multiple bacterial indicators on the same waterbody or waterbody segment, the determination of use support shall be based upon the use and application of all applicable tests and data.

(b) Screening levels.

(1) The screening level for fecal coliform shall be a density of 400 colonies per 100ml.

(2) The screening level for Escherichia coli shall be a density of 235 colonies per 100 ml in streams designated in OAC 785:45 as Scenic Rivers and in lakes, and 406 colonies per 100 ml in all other waters of the state designated as Primary Body Contact Recreation.

(3) The screening level for enterococci shall be a density of 61 colonies per 100 ml in streams designated in OAC 785:45 as Scenic Rivers and in lakes, and 108 colonies per 100 ml in all other waters of the state designated as Primary Body Contact Recreation.

(c) Fecal coliform:

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to fecal coliform if the geometric mean of 400 colonies per 100 ml is met and no greater than 25% of the sample concentrations from that waterbody exceed the screening level prescribed in (b) of this Section.

(2) The parameter of fecal coliform is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

(3) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to fecal coliform if the geometric mean of 400 colonies per 100 ml is not met, or greater than 25% of the sample concentrations from that waterbody exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

(d) Escherichia coli (E. coli):

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is met, or the sample concentrations from that waterbody taken during the recreation season do not exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

(2) The parameter of E. coli is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

(3) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is not met and any of the sample concentrations from that waterbody taken during the recreation season exceed a screening level prescribed in (b) of this Section.

(e) Enterococci:

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to enterococci if the geometric mean of 33 colonies per 100 ml is met, or the sample concentrations from that waterbody taken during the recreation season do not exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

(2) The parameter of enterococci is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

(3) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to enterococci if the geometric mean of 33 colonies per 100 ml is not met and any of the sample concentrations from that waterbody taken during the recreation season exceed a screening level prescribed in (b) of this Section.

Compliance with the Oklahoma WQS is based on meeting requirements for all three bacterial indicators. Where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, each indicator group must demonstrate compliance with the numeric criteria prescribed (OWRB 2006).

As stipulated in the WQS, utilization of the geometric mean to determine compliance for any of the three indicator bacteria depends on the collection of five samples within a 30-day period. For most stream segments in Oklahoma there are insufficient data available to calculate the 30-day geometric mean since most water quality samples are collected once a month. As a result, waterbodies placed on the 303(d) list for not supporting the PBCR are the result of individual samples exceeding the instantaneous criteria or the long-term geometric mean of individual samples exceeding the geometric mean criteria for each respective bacterial indicator. Targeting the instantaneous criterion established for the primary body contact recreation season (May 1st to September 30th) as the water quality goal for TMDLs corresponds to the basis for 303(d) listing and may be protective of the geometric mean criterion as well as the criteria for the secondary contact recreation season. However, both the instantaneous and geometric mean criteria for *E. coli* and Enterococci will be evaluated as water quality targets to ensure the most protective goal is established for each waterbody.

The specific data assessment method for listing indicator bacteria based on instantaneous or single sample criterion is detailed in Oklahoma's 2004 Integrated Report. As stated in the report, a minimum of 10 samples collected between May 1st and September 30th (during the primary recreation season) is required to list a segment for *E. coli* and Enterococci.

A sample quantity exception exists for fecal coliform that allows waterbodies to be listed for nonsupport of PBCR if there are less than 10 samples. The assessment method states that if there are less than 10 samples and the existing sample set already assures a nonsupport determination, then the waterbody should be listed for TMDL development. This condition is true in any case where the small sample set demonstrates that at least three out of six samples exceed the single sample fecal coliform criterion. In this case if four more samples were available to meet minimum of 10 samples, this would still translate to >25 percent exceedance or nonsupport of PBCR (*i.e.,* three out of 10 samples = 33 percent exceedance). For *E. coli* and Enterococci, the 10-sample minimum was used, without exception, in attainment determination.

2.2 Problem Identification

Table 2-2 summarizes water quality data collected during primary body contact recreation season from the stream segments between 1999 and 2007 for each indicator bacteria. All the data within this time frame were used to support the decision to place specific waterbodies within the Study Area on the ODEQ 2008 303(d) list (ODEQ 2008). Water quality data from the primary and secondary contact recreation seasons are provided in Appendix A.

For the data collected between 1999 and 2007, when there is enough data to make an assessment, evidence of nonsupport of primary body contact recreation beneficial uses was observed for all three bacteria indicators in Sand Creek, Gray Horse Creek and Doga Creek. Nonsupport of PBCR was observed for Enterococci in both segments of Salt Creek (OK621200040010_00 & OK621200040010_10). There is not enough data in Little Chief Creek to assess the PBCR uses for Enterococci and E. Coli. Little Chief Creek was found supporting PBCR beneficial uses for Fecal Coliform. Table 2-3 summarizes the waterbodies requiring TMDLs for not supporting PBCR.

2.3 Water Quality Target

The Code of Federal Regulations (40 CFR §130.7(c)(1)) states that, "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards." For the waterbodies requiring TMDLs in this report, defining the water quality target is somewhat complicated by the use of three different bacterial indicators with three different numeric criteria for determining attainment of PBCR use as defined in the Oklahoma WQS. An individual water quality target is established for each bacterial indicator since each indicator group must demonstrate compliance with the numeric criteria prescribed in the Oklahoma WQS (OWRB 2006). As previously stated, because available bacteria data were collected on an approximate monthly basis (see Appendix A) instead of at least five samples over a 30–day period, data for these TMDLs are analyzed and presented in relation to the instantaneous criteria for fecal coliform and both the instantaneous and a long-term geometric mean for both *E. coli* and Enterococci.

All TMDLs for fecal coliform must take into account that no more than 25 percent of the samples may exceed the instantaneous numeric criteria. For *E. coli* and Enterococci, no more than 10 percent of samples may exceed instantaneous criteria. Since the attainability of stream beneficial uses for *E. coli* and Enterococci is based on the compliance of either the instantaneous or a long-term geometric mean criterion, percent reductions goals will be calculated for both criteria. TMDLs will be based on the percent reduction required to meet either the instantaneous or long-term geometric mean criterion, whichever is less.

The water quality target for each waterbody will also incorporate an explicit 10 percent MOS. For example, if fecal coliform is utilized to establish the TMDL, then the water quality target is 360 organisms per 100 milliliters (mL), 10 percent lower than the instantaneous water quality criteria (400/100 mL). For *E. coli* the instantaneous water quality target is 365 organisms/100 mL, which is 10 percent lower than the criterion value (406/100 mL), and the geometric mean water quality target is 113 organisms/100 mL, which is 10 percent lower than the criterion value (126/100 mL). For Enterococci the instantaneous water quality target is 97/100 mL, which is 10 percent lower than the criterion value (108/100 mL) and the geometric mean water quality target is 30 organisms/100 mL, which is 10 percent lower than the criterion value (33/100 mL).

Each water quality target will be used to determine the allowable bacteria load which is derived by using the actual or estimated flow record multiplied by the instream criteria minus a 10 percent MOS.

Table 2-2 Summary of Indicator Bacteria Samples from Primary Body Contact Recreation Season, 1999-2003

Waterbody ID	Waterbody Name	Indicator Bacteria	Water Quality Criterion (#/100ml)	Geo-Mean Concentration (count/100ml)	Number of Samples	Number of Samples Exceeding Single Sample Criterion	% of Samples Exceeding Single Sample Criterion	Reason for Listing Change
OK621200040010_00	Salt Creek	FC	400 / 400					
		ENT	108 / 33	89	12	6	50.0%	
		EC	406 / 126	120	12	4	33.3%	Delist: Geomean
OK621200040010_10	Salt Creek	FC	400 / 400	157	10	1	10.0%	Delist: <25%
		ENT	108 / 33	144	13	6	46.2%	
		EC	406 / 126	102	14	4	28.6%	Delist: Geomean
OK621200040070_00	Little Chief Creek	FC	400 / 400	244	10	2	20.0%	Delist: <25%
		ENT	108 / 33	364	1	0	0.0%	Low sample count
		EC	406 / 126	78	2	0	0.0%	Low sample count
OK621200010400_00	Gray Horse Creek	FC	400 / 400	286	10	4	40.0%	
		ENT	108 / 33	124	14	9	64.3%	
		EC	406 / 126	184	15	7	46.7%	
OK621200020020_00	Doga Creek	FC	400 / 400	527	9	6	66.7%	
		ENT	108 / 33	122	11	7	63.6%	
		EC	406 / 126	219	12	4	33.3%	
OK121400040010_00	Sand Creek	FC	400 / 400	277	11	3	27.3%	
		ENT	108 / 33	145	18	8	44.4%	
		EC	406 / 126	129	19	5	26.3%	

EC = E. coli; ENT = enterococci; FC = fecal coliform

Highlighted bacterial indicators require TMDL

Table 2-3 Waterbodies Requiring TMDLs for Not Supporting Primary Body Contact Recreation Use

WQM Station	Waterbody ID	Waterbody Name	Indicator Bacteria		
			FC	ENT	*E. coli*
OK621200-04-0010F	OK621200040010_00	Salt Creek		**X**	
OK621200-04-0010J OK621200-04-0010P	OK621200040010_10	Salt Creek		**X**	
OK621200-04-0070C	OK621200040070_00	Little Chief Creek			
OK621200-01-0400C OK621200-01-0400T	OK621200010400_00	Gray Horse Creek	**X**	**X**	**X**
OK621200-02-0020C OK621200-02-0020M	OK621200020020_00	Doga Creek	**X**	**X**	**X**
OK121400-04-0010F OK121400-04-0010T	OK121400040010_00	Sand Creek	**X**	**X**	X

ENT = enterococci; FC = fecal coliform

SECTION 3
POLLUTANT SOURCE ASSESSMENT

A source assessment characterizes known and suspected sources of pollutant loading to impaired waterbodies. Sources within a watershed are categorized and quantified to the extent that information is available. Bacteria originate from humans and warm-blooded animals; and sources may be point or nonpoint in nature.

Point sources are permitted through the NPDES program. NPDES-permitted facilities that discharge treated wastewater are required to monitor for one of the three bacterial indicators (fecal coliform, *E coli*, or Enterococci) in accordance with its permit. Nonpoint sources are diffuse sources that typically cannot be identified as entering a waterbody through a discrete conveyance at a single location. These sources may involve land activities that contribute bacteria to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES are considered nonpoint sources. The following discussion describes what is known regarding point and nonpoint sources of bacteria in the impaired watersheds.

3.1 NPDES-Permitted Facilities

Under 40CFR, §122.2, a point source is described as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Certain NPDES-permitted municipal plants are classified as no-discharge facilities. NPDES-permitted facilities classified as point sources that may contribute bacteria loading include:

- NPDES municipal wastewater treatment plants (WWTP);
- NPDES municipal no-discharge WWTP;
- NPDES municipal separate storm sewer discharge (MS4); and
- NPDES Concentrated Animal Feeding Operation (CAFO).

Continuous point source discharges such as WWTPs, could result in discharge of elevated concentrations of fecal coliform bacteria if the disinfection unit is not properly maintained, is of poor design, or if flow rates are above the disinfection capacity. While the no-discharge facilities do not discharge wastewater directly to a waterbody, it is possible that the collection systems associated with each facility may be a source of bacteria loading to surface waters. Stormwater runoff from MS4 areas, which is now regulated under the USEPA NPDES Program, can also contain high bacteria concentrations. There are no permitted MS4s within the study area. CAFOs are recognized by USEPA as significant sources of pollution, and may have the potential to cause serious impacts to water quality if not properly managed. There are no NPDES permitted CAFOs in the study area.

There are no NPDES permitted facilities of any type in the contributing watershed of Sand Creek, Doga Creek and Gray Horse Creek.

Two of the sub-watersheds in the Study Area OK621200040010_00 (lower Salt Creek) and OK621200040010_10 (upper Salt Creek) have a continuous point source discharger.

3.1.1 Continuous Point Source Discharges

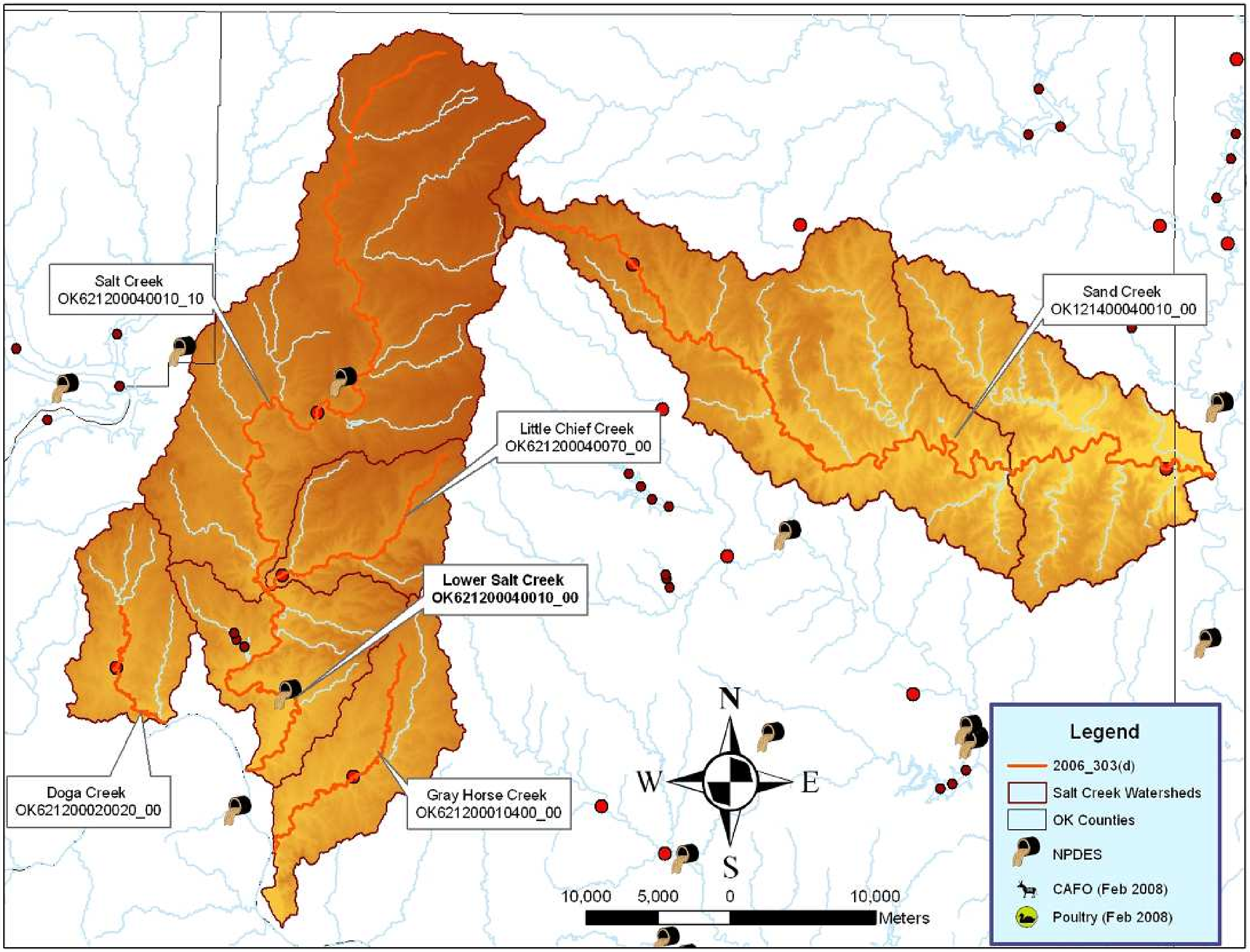
The location of the NPDES permitted facilities which discharge wastewater to surface waters addressed in these TMDLs are shown in Figure 3-1 and is listed in Table 3-1. For the purposes of the TMDLs calculated in Chapter 5, only facility types identified in Table 3-1 as Sewerage Systems are assumed to contribute bacteria loads within the watersheds of the impaired waterbodies.

Table 3-1 Point Source Discharges in the Study Area

NPDES Permit No.	Name	Receiving Water	Facility Type	County Name	Design Flow (mgd)	Active/ Inactive	Facility ID
OK0022993	City of Shidler	Salt Creek (OK621200040010_10)	Sewage	Osage	0.12	Active	S21205
OK0029017	Fairfax PWA	Salt Creek (OK621200040010_00)	Sewage	Osage	0.206	Active	S21207

Discharge Monitoring Reports (DMR) on bacteria were not available for either of the above facilities. Bacteria monitoring was not required in their NPDES permit.

Figure 3-1 Locations of NPDES-Permitted Facilities in the Study Area



3.1.2 NPDES No-Discharge Facilities and SSOs

There is no NPDES no-discharge facility in any of the sub-watersheds in the study area. (

Sanitary sewer overflows (SSO) from wastewater collection systems, although infrequent, can be a major source of fecal coliform loading to streams. SSOs have existed since the introduction of separate sanitary sewers, and most are caused by blockage of sewer pipes by grease, tree roots, and other debris that clog sewer lines, by sewer line breaks and leaks, cross connections with storm sewers, and inflow and infiltration of groundwater into sanitary sewers. SSOs are permit violations that must be addressed by the responsible NPDES permittee. The reporting of SSOs has been strongly encouraged by USEPA, primarily through enforcement and fines. While not all sewer overflows are reported, ODEQ has some data on SSOs available. There were 8 SSO occurrences in the Salt Creek Study Area on record which goes back to as early as 1989. the first occurrence was in January 1998 and the last in April 2008. A summary of the reported SSOs in the Salt Creek Study Area are provided in Table 3-2. Additional data on each individual SSO event are provided in Appendix B.

Table 3-2 Sanitary Sewer Overflow Summary

Facility Name	NPDES Permit No.	Receiving Water	Facility ID	Number of Occurrences	Date Range	
					From	To
Shidler	OK0022993	OK621200040010 Salt Creek	S21205	8	01/22/1998	04/11/2008

SSOs are a common result of the aging wastewater infrastructure around the state. DEQ has been ahead of other states and, in some cases EPA itself, in its handling of SSOs. Due to the widespread nature of the SSO problem, DEQ has focused its limited resources to first target SSOs that result in definitive environmental harm, such as fish kills, or lead to citizen complaints. All SSOs falling in these two categories are addressed through DEQ's formal enforcement process. A Notice of Violation (NOV) is first issued to the owner of the collection system and a Consent Order (CO) is negotiated between the owner and DEQ to establish a schedule for necessary collection system upgrades to eliminate future SSOs.

Another target area for DEQ is chronic SSOs from OPDES major facilities, those with a total design flow in excess of 1 MGD. DEQ periodically reviews the bypass reports submitted by these major facilities and identifies problem areas and chronic SSOs. When these problems are attributable to wet weather, DEQ endeavors to enter into a CO with the owner of the collection system to establish a schedule for necessary repairs. When the problems seem to be dry weather-related, DEQ will encourage the owner of the collection system to implement the proposed Capacity, Management, Operation, and Maintenance (CMOM) guidelines aimed at minimizing or eliminating dry weather SSOs. This is often accomplished through entering into a Consent Order to establish a schedule for implementation and annual auditing of the CMOM program.

All SSOs are considered unpermitted discharges under State statute and DEQ regulations. The smaller towns have a smaller reserve, are more likely to use utility revenue for general purposes, and/or tend to budget less for ongoing and/or preventive maintenance. If and when

DEQ becomes aware of chronic SSOs (more than one from a single location in a year) or receives a complaint about an SSO in a smaller community, DEQ will pursue enforcement action. Enforcement almost always begins with the issuance of an NOV and, if the problem is not corrected by a long-term solution, DEQ will enter into a CO with the facility for a long-term solution. Long-term solutions usually begin with sanitary sewer evaluation surveys (SSESs). Based on the result of the SSES, the facilities can prioritize and take corrective action.

3.1.3 NPDES Municipal Separate Storm Sewer Discharge

Phase I MS4

In 1990 the USEPA developed rules establishing Phase I of the NPDES Stormwater Program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4) and then discharged into local water bodies (USEPA 2005). Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipal-owned operations, and hazardous waste treatment. There are no Phase I MS4 permits in the Study Area.

Phase II MS4

Phase II of the rule extends coverage of the NPDES Stormwater Program to certain small MS4s. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES Stormwater Program. Phase II requires operators of regulated small MS4s to obtain NPDES permits and develop a stormwater management program. Programs are designed to reduce discharges of pollutants to the "maximum extent practicable," protect water quality, and satisfy appropriate water quality requirements of the CWA. Small MS4 stormwater programs must address the following minimum control measures:

- Public Education and Outreach;
- Public Participation/Involvement;
- Illicit Discharge Detection and Elimination;
- Construction Site Runoff Control;
- Post- Construction Runoff Control; and
- Pollution Prevention/Good Housekeeping.

The small MS4 General Permit for communities in Oklahoma became effective on February 8, 2005. There are no permitted MS4s within the study area. ODEQ provides information on the current status of its MS4 program on its website, found at:

http://www.deq.state.ok.us/WQDnew/stormwater/ms4/

3.1.4 Concentrated Animal Feeding Operations

There are no NPDES-permitted CAFO facilities within the Study Area.

3.2 Nonpoint Sources

Nonpoint sources include those sources that cannot be identified as entering the waterbody at a specific location. Bacteria originate from rural, suburban, and urban areas. The following section describes possible major nonpoint sources contributing fecal coliform loading within the Study Area.

These sources include wildlife, various agricultural activities and domesticated animals, land application fields, urban runoff, failing onsite wastewater disposal (OSWD) systems, and domestic pets. As previously stated in Subsection 3.1, there are no NPDES permitted facilities of any type in the contributing watershed of Sand Creek, Gray Horse Creek and Doga Creek; therefore, nonsupport of PBCR use for these sub-watersheds is caused by nonpoint sources of bacteria only.

Bacteria associated with urban runoff can emanate from humans, wildlife, commercially raised farm animals, and domestic pets. Water quality data collected from streams draining urban communities often show existing concentrations of fecal coliform bacteria at levels greater than a state's instantaneous standards. A study under USEPA's National Urban Runoff Project indicated that the average fecal coliform concentration from 14 watersheds in different areas within the United States was approximately 15,000 /100 mL in stormwater runoff (USEPA 1983). Water quality data collected from streams draining many of the nonpermitted communities show existing loads of fecal coliform bacteria at levels greater than the State's instantaneous standards. Best management practices (BMP) such as buffer strips, repair of leaking sewage collection systems, elimination of illicit discharges and proper disposal of domestic animal waste, can reduce bacteria loading to waterbodies.

3.2.1 Wildlife

Fecal coliform bacteria are produced by all warm-blooded animals, including wildlife such as mammals and birds. In developing bacteria TMDLs it is important to identify the potential for bacteria contributions from wildlife by watershed. Wildlife is naturally attracted to riparian corridors of streams and rivers. With direct access to the stream channel, wildlife can be a concentrated source of bacteria loading to a waterbody. Fecal coliform bacteria from wildlife are also deposited onto land surfaces, where it may be washed into nearby streams by rainfall runoff. Currently there are insufficient data available to estimate populations and spatial distribution of wildlife and avian species by watershed. Consequently it is difficult to assess the magnitude of bacteria contributions from wildlife species as a general category.

However, adequate data are available by county to estimate the number of deer by watershed. This report assumes that deer habitat includes forests, croplands, and pastures. Using Oklahoma Department of Wildlife Conservation county data, the population of deer can be roughly estimated from the actual number of deer harvested and harvest rate estimates. Because harvest success varies from year to year based on weather and other factors, the average harvest from 1999 to 2003 was combined with an estimated annual harvest rate of 20 percent to predict deer population by county. Using the estimated deer population by county and the percentage of the watershed area within each county, a wild deer population can be calculated for each watershed. Table 3-3 provides the estimated number of deer for each watershed.

Table 3-3 Estimated Deer Populations

Waterbody ID	Waterbody Name	Deer	Acre
OK621200040010_00	Salt Creek	40	32,060
OK621200040010_10	Salt Creek	164	130,796
OK621200010400_00	Gray Horse Creek	43	31,658
OK621200020020_00	Doga Creek	29	23,354
OK121400040010_00	Sand Creek	257	154,800

According to a study conducted by ASAE (the American Society of Agricultural Engineers), deer release approximately $5x10^8$ fecal coliform units per animal per day (ASAE 1999). Although only a fraction of the total fecal coliform loading produced by the deer population may actually enter a waterbody, the estimated fecal coliform production for deer provided in Table 3-4 in cfu/day provides a relative magnitude of loading in each watershed.

Table 3-4 Estimated Fecal Coliform Production for Deer

Waterbody ID	Waterbody Name	Watershed Area (acres)	Wild Deer Population	Estimated Wild Deer per acre	Fecal Production (x 10^9 cfu/day) of Deer Population
OK621200040010_00	Salt Creek	32,060	40	0.0012	20
OK621200040010_10	Salt Creek	130,796	164	0.0013	82
OK621200010400_00	Gray Horse Creek	31,658	43	0.0014	22
OK621200020020_00	Doga Creek	23,354	29	0.0012	15
OK121400040010_00	Sand Creek	154,800	257	0.0017	129

3.2.2 Non-Permitted Agricultural Activities and Domesticated Animals

There are a number of non-permitted agricultural activities that can also be sources of fecal bacteria loading. Agricultural activities of greatest concern are typically those associated with livestock operations (Drapcho and Hubbs 2002). The following are examples of commercially raised farm animal activities that can contribute to bacteria sources:

- Processed commercially raised farm animal manure is often applied to fields as fertilizer, and can contribute to fecal bacteria loading to waterbodies if washed into streams by runoff.
- Animals grazing in pastures deposit manure containing fecal bacteria onto land surfaces. These bacteria may be washed into waterbodies by runoff.

- Animals often have direct access to waterbodies and can provide a concentrated source of fecal bacteria loading directly into streams.

Table 3-5 provides estimated numbers of commercially raised farm animals by watershed based on the 2002 U.S. Department of Agriculture (USDA) county agricultural census data (USDA 2002). The estimated animal populations in Table 3-5 were derived by using the percentage of the watershed within each county. Because the watersheds are generally much smaller than the counties, and commercially raised farm animals are not evenly distributed across counties or constant with time, these are rough estimates only. Cattle generate the largest amount of fecal coliform and often have direct access to the impaired waterbodies.

Detailed information is not available to describe or quantify the relationship between instream concentrations of bacteria and land application of manure. The estimated acreage by watershed where manure was applied in 2002 is shown in Table 3-5. These estimates are also based on the county level reports from the 2002 USDA county agricultural census, and thus represent approximations of the land application area in each watershed. Because of the lack of specific data, for the purpose of these TMDLs, land application of animal manure is not quantified in Table 3-6 but is considered a potential source of bacteria loading to the waterbodies in the Study Area. Most poultry feeding operations are regulated by ODAFF, and are required to land apply chicken waste in accordance with their Animal Waste Management Plans or Comprehensive Nutrient Management Plans. While these plans are not designed to control bacteria loading, best management practices and conservation measures, if properly implemented, could greatly reduce the contribution of bacteria from this group of animals to the watershed.

According to a study conducted by the ASAE, the daily fecal coliform production rates by species were estimated as follows (ASAE 1999):

- Beef cattle release approximately 1.04E+11 fecal coliform counts per animal per day;
- Dairy cattle release approximately 1.01E+11 per animal per day
- Swine release approximately 1.08E+10 per animal per day
- Chickens release approximately 1.36E+08 per animal per day
- Sheep release approximately 1.20E+10 per animal per day
- Horses release approximately 4.20E+08 per animal per day;
- Turkey release approximately 9.30E+07 per animal per day
- Ducks release approximately 2.43E+09 per animal per day
- Geese release approximately 4.90E+10 per animal per day

Using the estimated animal populations and the fecal coliform production rates from ASAE, an estimate of fecal coliform production from each group of commercially raised farm animals was calculated in each watershed of the Study Area in Table 3-6. Note that only a small fraction of these fecal coliform are expected to represent loading into waterbodies, either washed into streams by runoff or by direct deposition from wading animals. Cattle appear to represent the largest source of fecal bacteria.

According to data provided by Oklahoma Department of Agriculture, Food, and Forestry (ODAFF), there are no CAFOs or poultry operations in the study area (Figure 3-1).

Table 3-5 Commercially Raised Farm Animals and Manure Application Area Estimates by Watershed

Waterbody ID	Waterbody Name	Cattle & Calves-all	Dairy Cows	Horses & Ponies	Goats	Sheep & Lambs	Hogs & Pigs	Ducks & Geese	Chicken & Turkeys	Acres of Manure Application
OK621200040010_00	Salt Creek	3,768	3	102	0	27	12	5	76	17
OK621200040010_10	Salt Creek	15,372	13	415	0	109	47	18	309	67
OK621200010400_00	Gray Horse Creek	3,720	3	101	0	27	11	5	75	17
OK621200020020_00	Doga Creek	2,746	2	74	0	19	8	3	55	10
OK121400040010_00	Sand Creek	18,261	15	521	0	136	54	22	378	116

Table 3-6 Fecal Coliform Production Estimates for Commercially Raised Farm Animals ($x10^9$ number/day)

Waterbody ID	Waterbody Name	Cattle & Calves-all	Dairy Cows	Horses & Ponies	Goats	Sheep & Lambs	Hogs & Pigs	Ducks & Geese	Chickens & Turkeys	Total
OK621200040010_00	Salt Creek	391,504	333	43	N/A	321	125	11	10	392,347
OK621200040010_10	Salt Creek	1,597,237	1,360	174	N/A	1,309	510	45	42	1,600,678
OK621200010400_00	Gray Horse Creek	386,622	301	42	N/A	320	122	11	10	387,429
OK621200020020_00	Doga Creek	285,367	224	31	N/A	225	90	8	7	285,952
OK121400040010_00	Sand Creek	1,897,511	1,542	219	N/A	1,635	578	53	51	1,901,589

3.2.3 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

ODEQ is responsible for implementing the regulations of Title 252, Chapter 641 of the Oklahoma Administrative Code, which define design standards for individual and small public onsite sewage disposal systems (ODEQ 2008a). OSWD systems and illicit discharges can be a source of bacteria loading to streams and rivers. Bacteria loading from failing OSWD systems can be transported to streams in a variety of ways, including runoff from surface ponding or through groundwater. Fecal coliform-contaminated groundwater discharges to creeks through springs and seeps.

To estimate the potential magnitude of OSWDs fecal bacteria loading, the number of OSWD systems was estimated for each watershed. The estimate of OSWD systems was derived by using data from the 1990 U.S. Census because this data was not available in the 2000 U.S. Census. The estimate was then prorated based on the population data from both the 1990 and 2000 U.S. Census. The density of OSWD systems within each watershed was estimated by dividing the number of OSWD systems in each census block by the number of acres in each census block. This density was then applied to the number of acres of each census block within a waterbody watershed. Census blocks crossing a watershed boundary required additional calculation to estimate the number of OSWD systems based on the proportion of the census tracking falling within each watershed. This step involved adding all OSWD systems for each whole or partial census block.

Over time, most OSWD systems operating at full capacity will fail. OSWD system failures are proportional to the adequacy of a state’s minimum design criteria (Hall 2002). The 1995 American Housing Survey conducted by the U.S. Census Bureau estimates that, nationwide, 10 percent of occupied homes with OSWD systems experience malfunctions during the year (U.S. Census Bureau 1995). A study conducted by Reed, Stowe & Yanke, LLC (2001) reported that approximately 12 percent of the OSWD systems in northeast Texas (adjacent to the study area) were chronically malfunctioning. Most studies estimate that the minimum lot size necessary to ensure against contamination is roughly one-half to one acre (Hall 2002). Some studies, however, found that lot sizes in this range or even larger could still cause contamination of ground or surface water (University of Florida 1987). It is estimated that areas with more than 40 OSWD systems per square mile (6.25 septic systems per 100 acres) can be considered to have potential contamination problems (Canter and Knox 1986). Table 3-7 summarizes estimates of sewered and unsewered households for each watershed in the study area.

Table 3-7 Estimates of Sewered and Unsewered Households

Waterbody ID	Waterbody Name	Public Sewer	Septic Tank	Other Means	Housing Units	% Sewered
OK621200040010_00	Salt Creek	151	51	2	204	74%
OK621200040010_10	Salt Creek	618	207	7	833	74%
OK621200010400_00	Gray Horse Creek	1	36	1	38	2%
OK621200020020_00	Doga Creek	2	81	2	84	2%
OK121400040010_00	Sand Creek	1,488	730	29	2,247	66%

For the purpose of estimating fecal coliform loading in watersheds, an OSWD failure rate of 8 percent was used. Using this 8 percent failure rate, calculations were made to characterize fecal coliform loads in each watershed.

Fecal coliform loads were estimated using the following equation (USEPA 2001):

$$\#\frac{counts}{day} = (\#\,Failing\_systems)\times\left(\frac{10^6\,counts}{100ml}\right)\times\left(\frac{70gal}{personday}\right)\times\left(\#\frac{person}{household}\right)\times\left(3785.2\frac{ml}{gal}\right)$$

The average of number of people per household was calculated to be 2.48 for counties in the Study Area (U.S. Census Bureau 2000). Approximately 70 gallons of wastewater was estimated to be produced on average per person per day (Metcalf and Eddy 1991). The fecal coliform concentration in septic tank effluent was estimated to be 10^6 per 100 mL of effluent based on reported concentrations from a number of published reports (Metcalf and Eddy 1991, Canter and Knox 1985; Cogger and Carlile 1984). Using this information, the estimated load from failing septic systems within the watersheds was summarized below in Table 3-8.

Table 3-8 Estimated Fecal Coliform Load from OSWD Systems

Waterbody ID	Waterbody Name	Acres	Septic Tank	# of Failing Septic Tanks	Estimated Loads from Septic Tanks (x 10^9 counts/day)
OK621200040010_00	Salt Creek	32,060	51	6	42
OK621200040010_10	Salt Creek	130,796	207	25	170
OK621200010400_00	Gray Horse Creek	31,658	36	4	30
OK621200020020_00	Doga Creek	23,354	81	10	66
OK121400040010_00	Sand Creek	154,800	730	88	599

3.2.4 Domestic Pets

Fecal matter from dogs and cats, which is transported to streams by runoff from urban and suburban areas can be a potential source of bacteria loading. On average nationally, there are 0.58 dogs per household and 0.66 cats per household (American Veterinary Medical Association 2004). Using the U.S. census data at the block level (U.S. Census Bureau 2000), dog and cat populations can be estimated for each watershed. Table 3-9 summarizes the estimated number of dogs and cats for the watersheds of the Study Area.

Table 3-9 Estimated Numbers of Pets

Waterbody ID	Waterbody Name	Housing Units	Dogs	Cats
OK621200040010_00	Salt Creek	204	118	135
OK621200040010_10	Salt Creek	833	483	550
OK621200010400_00	Gray Horse Creek	38	22	25
OK621200020020_00	Doga Creek	84	49	55
OK121400040010_00	Sand Creek	2,247	1,303	1,483

Table 3-10 provides an estimate of the fecal coliform load from pets. These estimates are based on estimated fecal coliform production rates of 5.4×10^8 per day for cats and 3.3×10^9 per day for dogs (Schueler 2000).

Table 3-10 Estimated Fecal Coliform Daily Production by Pets (x 10^9)

Waterbody ID	Waterbody Name	Dogs	Cats	Total
OK621200040010_00	Salt Creek	390	73	463
OK621200040010_10	Salt Creek	1,594	297	1,891
OK621200010400_00	Gray Horse Creek	73	14	86
OK621200020020_00	Doga Creek	161	30	191
OK121400040010_00	Sand Creek	4,301	801	5,102

3.3 Summary of Bacteria Sources

NPDES-permitted facilities operate in a few of the watersheds in the Study Area but most of the point sources are relatively minor and for the most part tend to meet instream water quality criteria in their effluent. Thus, nonpoint sources are considered to be the major source of bacteria loading in each watershed. Table 3-11 summarizes the suspected sources of bacteria loading in each impaired watershed.

Table 3-11 Estimated Major Source of Bacteria Loading by Watershed

Waterbody ID	Waterbody Name	Point Sources	Nonpoint Sources	Major Source
OK621200040010_00	Salt Creek	Yes	Yes	Nonpoint
OK621200040010_10	Salt Creek	Yes	Yes	Nonpoint
OK621200010400_00	Gray Horse Creek	No	Yes	Nonpoint
OK621200020020_00	Doga Creek	No	Yes	Nonpoint
OK121400040010_00	Sand Creek	No	Yes	Nonpoint

Table 3-12 below provides a summary of the estimated fecal coliform loads in percentage for the four major nonpoint source categories (commercially raised farm animals, pets, deer and septic tanks) that are contributing to the elevated bacteria concentrations in each watershed. Commercially raised farm animals are estimated to be the primary contributors of fecal coliform loading to land surfaces. It must be noted that while no data are available to estimate populations and fecal loading of wildlife other than deer, a number of bacteria source tracking studies demonstrate that wild birds and mammals represent a major source of the fecal bacteria found in streams.

The magnitude of loading to a stream may not reflect the magnitude of loading to land surfaces. While no studies quantify these effects, bacteria may die off or survive at different rates depending on the manure characteristics and a number of other environmental conditions. Manure handling practices, use of BMPs, and relative location to streams can also affect stream loading. Also, the structural properties of some manures, such as cow patties, may limit their washoff into streams by runoff. Because litter is applied in a pulverized form, it could be a larger source during storm runoff events. The Shoal Creek report showed that poultry litter was about 71% of the high flow load and cow pats contributed only about 28% of it (Missouri Department of Natural Resources, 2003). The Shoal Creek report also showed that poultry litter was insignificant under low flow conditions up to 50% frequency. In contrast, malfunctioning septic tank effluent may be present in pools on the surface, or in shallow groundwater, which may enhance its conveyance to streams.

Table 3-12 Summary of Daily Fecal Coliform Load Estimates from Nonpoint Sources to Land Surfaces

Waterbody ID	Waterbody Name	Commercially Raised Farm Animals	Pets	Deer	Septic Tanks
OK621200040010_00	Salt Creek	99.87%	0.12%	0.01%	0.01%
OK621200040010_10	Salt Creek	99.87%	0.12%	0.01%	0.01%
OK621200010400_00	Gray Horse Creek	99.96%	0.02%	0.01%	0.01%
OK621200020020_00	Doga Creek	99.91%	0.07%	0.01%	0.02%
OK121400040010_00	Sand Creek	99.69%	0.27%	0.01%	0.03%

SECTION 4
TECHNICAL APPROACH AND METHODS

The objective of a TMDL is to estimate allowable pollutant loads and to allocate these loads to the known pollutant sources in the watershed so appropriate control measures can be implemented and the WQS achieved. A TMDL is expressed as the sum of three elements as described in the following mathematical equation:

$$TMDL = \Sigma\ WLA + \Sigma\ LA + MOS$$

The WLA is the portion of the TMDL allocated to existing and future point sources. The LA is the portion of the TMDL allocated to nonpoint sources, including natural background sources. The MOS is intended to ensure that WQSs will be met. Thus, the allowable pollutant load that can be allocated to point and nonpoint sources can then be defined as the TMDL minus the MOS.

40 CFR, §130.2(1), states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For fecal coliform, *E. coli*, or Enterococci bacteria, TMDLs are expressed as colony-forming units per day, where possible, or as a percent reduction goal (PRG), and represent the maximum one-day load the stream can assimilate while still attaining the WQS.

4.1 Using Load Duration Curves to Develop TMDLs

The TMDL calculations presented in this report are derived from load duration curves (LDC). LDCs facilitate rapid development of TMDLs, and as a TMDL development tool are effective at identifying whether impairments are associated with point or nonpoint sources. The technical approach for using LDCs for TMDL development includes the four following steps that are described in Subsections 4.2 through 4.4 below:

- Preparing flow duration curves for gaged and ungaged stream segments;
- Estimating existing bacteria loading in the receiving water using ambient water quality data;
- Using LDCs to identify the critical condition that will dictate loading reductions necessary to attain WQS; and
- Interpreting LDCs to derive TMDL elements – WLA, LA, MOS, and PRG.

Historically, in developing WLAs for pollutants from point sources, it was customary to designate a critical low flow condition (*e.g.*, 7Q2) at which the maximum permissible loading was calculated. As water quality management efforts expanded in scope to quantitatively address nonpoint sources of pollution and types of pollutants, it became clear that this single critical low flow condition was inadequate to ensure adequate water quality across a range of flow conditions. Use of the LDC obviates the need to determine a design storm or selected flow recurrence interval with which to characterize the appropriate flow level for the assessment of critical conditions. For waterbodies impacted by both point and nonpoint sources, the "nonpoint source critical condition" would typically occur during high flows, when rainfall runoff would contribute the bulk of the pollutant load, while the "point source critical condition" would typically occur during low flows, when WWTP effluents would dominate the base flow of the impaired water. However, flow range is only a general indicator of the relative proportion of point/nonpoint contributions. It is not used in this report to quantify point source or nonpoint source contributions. Violations that occur during low flows may not be caused exclusively by point sources. Violations have been noted in some watersheds that contain no point sources. Research has shown that bacteria loading in streams during low flow conditions may be due to direct deposit of cattle manure into streams and faulty septic tank/lateral field systems.

LDCs display the maximum allowable load over the complete range of flow conditions by a line using the calculation of flow multiplied by the water quality criterion. The TMDL can be expressed as a continuous function of flow, equal to the line, or as a discrete value derived from a specific flow condition.

4.2 Development of Flow Duration Curves

Flow duration curves serve as the foundation of LDCs and are graphical representations of the flow characteristics of a stream at a given site. Flow duration curves utilize the historical hydrologic record from stream gages to forecast future recurrence frequencies. Many streams throughout Oklahoma do not have long term flow data and therefore, flow frequencies must be estimated. The most basic method to estimate flows at an ungaged site involves 1) identifying an upstream or downstream flow gage; 2) calculating the contributing drainage areas of the ungaged sites and the flow gage; and 3) calculating daily flows at the ungaged site by using the flow at the gaged site multiplied by the drainage area ratio. The more complex approach used here in this TMDL report, also considers watershed differences in rainfall, land use, and the hydrologic properties of soil that govern runoff and retention. More than one upstream flow gage may also be considered. A more detailed explanation of the methods for estimating flow at ungaged streams is provided in Appendix C.

Flow duration curves are a type of cumulative distribution function. The flow duration curve represents the fraction of flow observations that exceed a given flow at the site of interest. The observed flow values are first ranked from highest to lowest then, for each observation, the percentage of observations exceeding that flow is calculated. The flow value is read from the ordinate (y-axis), which is typically on a logarithmic scale since the high flows would otherwise overwhelm the low flows. The flow exceedance frequency is read from the abscissa, which is numbered from 0 to 100 percent, and may or may not be logarithmic. The lowest measured flow occurs at an exceedance frequency of 100 percent, indicating that flow has equaled or exceeded this value 100 percent of the time, while the highest measured flow is found at an exceedance frequency of 0 percent. The median flow occurs at a flow exceedance frequency of 50 percent. The flow exceedance percentiles for each stream segment addressed in this report are provided in Appendix C.

While the number of observations required to develop a flow duration curve is not rigorously specified, a flow duration curve is usually based on more than 1 year of observations, and encompasses inter-annual and seasonal variation. Ideally, the drought of record and flood of record are included in the observations. For this purpose, the long-term flow gaging stations operated by the USGS are utilized (USGS 2007a).

A typical semi-log flow duration curve exhibits a sigmoidal shape, bending upward near a flow exceedance frequency value of 0 percent and downward at a frequency near 100 percent, often with a relatively constant slope in between. For sites that on occasion exhibit no flow, the curve will intersect the abscissa at a frequency less than 100 percent. As the number of observations at a site increases, the line of the LDC tends to appear smoother. However, at extreme low and high flow values, flow duration curves may exhibit a "stair step" effect due to the USGS flow data rounding conventions near the limits of quantitation.

Figures 4-1 through 4-5 are flow duration curves for each impaired waterbody during the primary body contact recreation season. The flow duration curve for Sand Creek was based on measured flows at USGS gage station 07174600 (Sand Creek at Okesa, OK). The flow period used for this station was 1959 through 1994.

No flow gages exist on Salt Creek, Gray Horse Creek and Doga Creek. The flow duration curves for these streams were estimated using the watershed area ratio method based on measured flows at USGS gage station 07174600 (Sand Creek at Okesa, OK).

Figure 4-1 Flow Duration Curve for Salt Creek (OK620200040010_00)

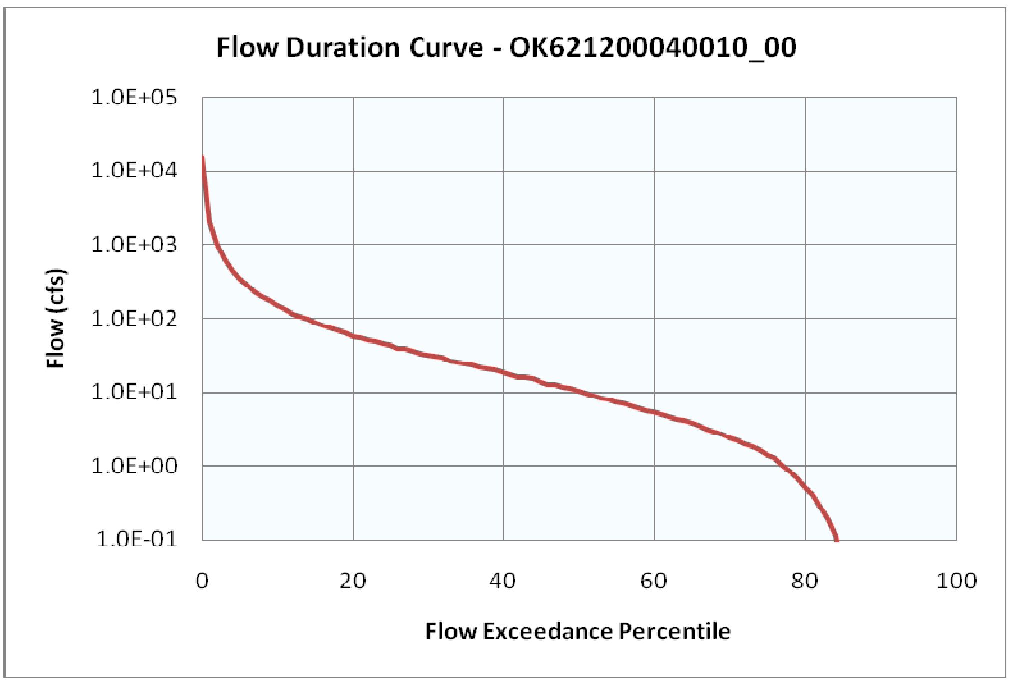


Figure 4-2 Flow Duration Curve for Salt Creek (OK620200040010_10)

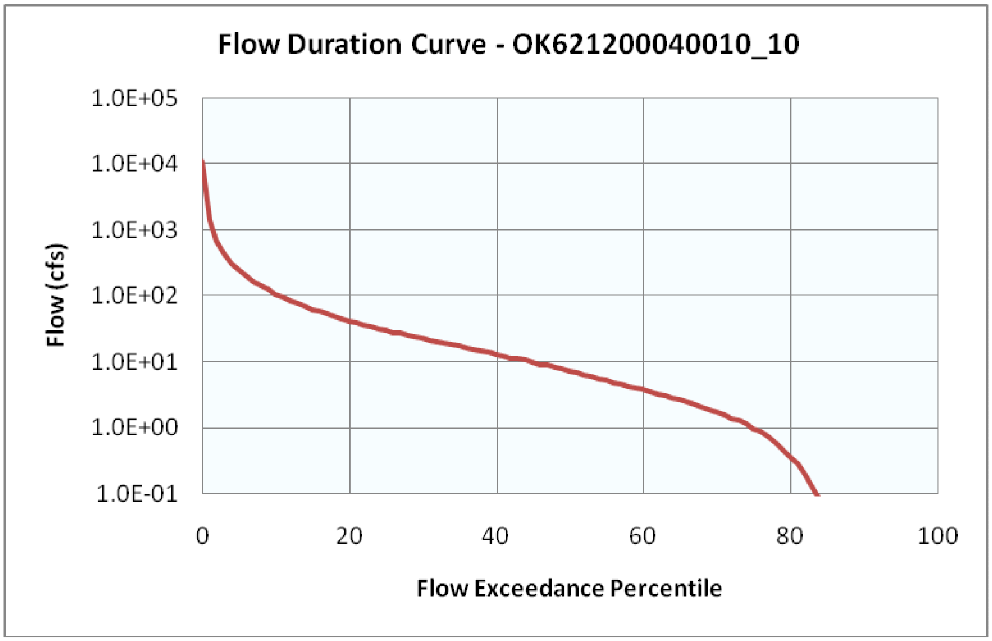


Figure 4-3 Flow Duration Curve for Gray Horse Creek (OK621200010400_00)

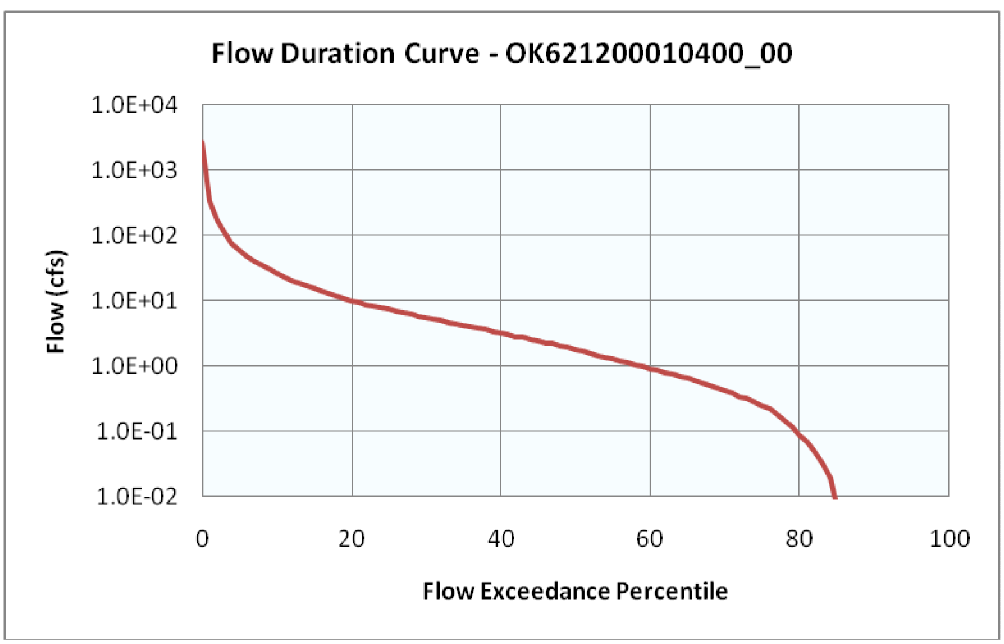


Figure 4-4 Flow Duration Curve for Doga Creek (OK621200020020_00)

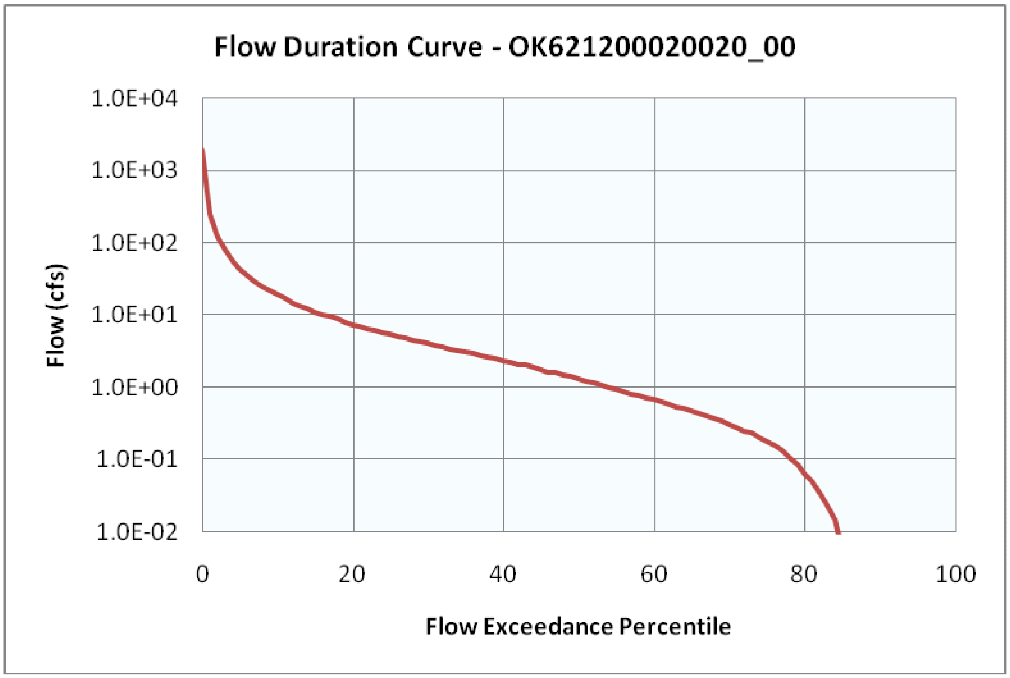
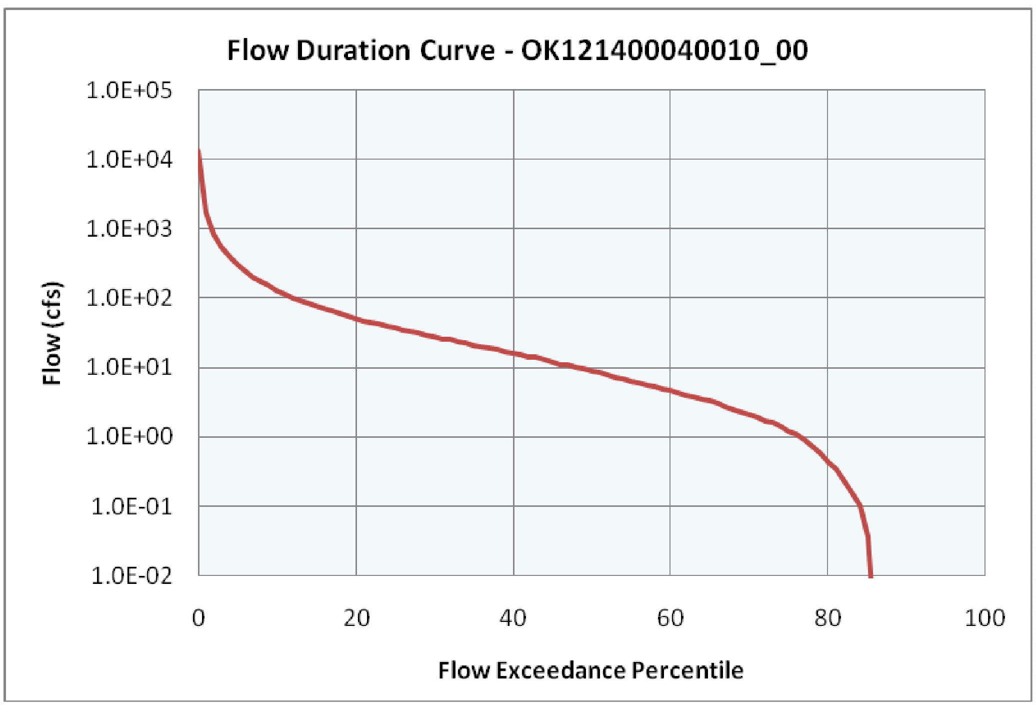


Figure 4-5 Flow Duration Curve for Sand Creek (OK121400040010_00)



The USGS National Water Information System serves as the primary source of flow measurements for the application. All available daily average flow values for all gages in Oklahoma, as well as the nearest upstream and downstream gages in adjacent states, were retrieved for use in the application. The application includes a data update module that automatically downloads the most recent USGS data and appends it to the existing flow database.

Some instantaneous flow measurements were available from various agencies. These were not combined with the daily average flows or used in calculating flow percentiles, but were matched to bacteria grab measurements collected at the same site and time. When available, these instantaneous flow measurements were used in lieu of the daily average flow to calculate instantaneous bacteria loads.

4.3 Estimating Current Point and Nonpoint Loading

Another key step in the use of LDCs for TMDL development is the estimation of existing bacteria loading from point and nonpoint sources and the display of this loading in relation to the TMDL. In Oklahoma, WWTPs that discharge treated sanitary wastewater must meet the state WQSs for fecal bacteria at the point of discharge. However, for TMDL analysis it is necessary to understand the relative contribution of WWTPs to the overall pollutant loading and its general compliance with required effluent limits. The monthly bacteria load for continuous point source dischargers is estimated by multiplying the monthly average flow rates by the monthly geometric mean using a conversion factor. The current pollutant loading from each permitted point source discharge is calculated using the equation below.

*Point Source Loading = monthly average flow rates (mgd) * geometric mean of corresponding fecal coliform concentration * unit conversion factor*

Where:

unit conversion factor = 37,854,120 100-ml/million gallons

It is difficult to estimate current nonpoint loading due to lack of specific water quality and flow information that would assist in estimating the relative proportion of non-specific sources within the watershed. Therefore, existing instream loads minus the point source loads were used as an estimate for nonpoint loading.

4.4 Development of TMDLs Using Load Duration Curves

The final step in the TMDL calculation process involves a group of additional computations derived from the preparation of LDCs. These computations are necessary to derive a PRG (which is one method of presenting how much bacteria loading must be reduced to meet WQSs in the impaired watershed).

Step 1: Generate Bacteria LDCs. LDCs are similar in appearance to flow duration curves; however, the ordinate is expressed in terms of a bacteria load in cfu/day. The curve represents the single sample water quality criterion for fecal coliform (400 cfu/100 mL), *E. coli* (406 cfu/100 mL), or Enterococci (108 cfu/100 mL) expressed in terms of a load through multiplication by the continuum of flows historically observed at this site. The basic steps to generating an LDC involve:

- obtaining daily flow data for the site of interest from the USGS;

- sorting the flow data and calculating flow exceedance percentiles for the time period and season of interest;
- obtaining the water quality data from the primary body contact recreation season (May 1 through September 30);
- matching the water quality observations with the flow data from the same date;
- display a curve on a plot that represents the allowable load multiplied by the actual or estimated flow by the WQS for each respective indicator;
- multiplying the flow by the water quality parameter concentration to calculate daily loads; then
- plotting the flow exceedance percentiles and daily load observations in a load duration plot.

The culmination of these steps is expressed in the following formula, which is displayed on the LDC as the TMDL curve:

TMDL (cfu/day) = WQS * flow (cfs) * unit conversion factor

Where: WQS = 400 cfu /100 ml (Fecal coliform); 406 cfu/100 ml (E. coli); or 108 cfu/100 ml (Enterococci)

unit conversion factor = 24,465,525 ml*s / ft3*day

The flow exceedance frequency (x-value of each point) is obtained by looking up the historical exceedance frequency of the measured or estimated flow, in other words, the percent of historical observations that equal or exceed the measured or estimated flow. Historical observations of bacteria concentration are paired with flow data and are plotted on the LDC. The fecal coliform load (or the y-value of each point) is calculated by multiplying the fecal coliform concentration (colonies/100 mL) by the instantaneous flow (cubic feet per second) at the same site and time, with appropriate volumetric and time unit conversions. Fecal coliform/*E. coli*/Enterococci loads representing exceedance of water quality criteria fall above the water quality criterion line.

Only those flows and water quality samples observed in the months comprising the primary body contact recreation season are used to generate the LDCs. It is inappropriate to compare single sample bacteria observations and instantaneous or daily flow durations to a 30-day geometric mean water quality criterion in the LDC.

As noted earlier, runoff has a strong influence on loading of nonpoint pollution. Yet flows do not always correspond directly to local runoff; high flows may occur in dry weather and runoff influence may be observed with low or moderate flows.

Step 2: Develop LDCs with MOS. An LDC depicting slightly lower estimates than the TMDL is developed to represent the TMDL with MOS. The MOS may be defined explicitly or implicitly. A typical explicit approach would reserve some fraction of the TMDL (*e.g.,* 10%) as the MOS. In an implicit approach, conservative assumptions used in developing the TMDL are relied upon to provide an MOS to assure that WQSs are attained.

For the TMDLs in this report, an explicit MOS of 10 percent of the TMDL value (10% of the instantaneous water quality criterion) has been selected.

Step 3: Calculate WLA. As previously stated, the pollutant load allocation for point sources is defined by the WLA. A point source can be either a wastewater (continuous) or stormwater (MS4) discharge. Stormwater point sources are typically associated with urban and industrialized areas, and recent USEPA guidance includes NPDES-permitted stormwater discharges as point source discharges and, therefore, part of the WLA.

The LDC approach recognizes that the assimilative capacity of a waterbody depends on the flow, and that maximum allowable loading will vary with flow condition. TMDLs can be expressed in terms of maximum allowable concentrations, or as different maximum loads allowable under different flow conditions, rather than single maximum load values. This concentration-based approach meets the requirements of 40 CFR, 130.2(i) for expressing TMDLs "in terms of mass per time, toxicity, or other appropriate measures" and is consistent with USEPA's Protocol for Developing Pathogen TMDLs (USEPA 2001).

WLA for WWTP. WLAs may be set to zero for watersheds with no existing or planned continuous permitted point sources. For watersheds with permitted point sources, WLAs may be derived from NPDES permit limits. A WLA may be calculated for each active NPDES wastewater discharger using a mass balance approach as shown in the equation below. The permitted average flow rate used for each point source discharge and the water quality criterion concentration are used to estimate the WLA for each wastewater facility. All WLA values for each NPDES wastewater discharger are then summed to represent the total WLA for the watershed.

WLA (cfu/day) = WQS * flow * unit conversion factor

Where:

Where: WQS = 200 cfu /100 ml (Fecal coliform); 126 cfu/100 ml (E. coli); or 33 cfu/100 ml (Enterococci)

flow (10^6 gal/day) = permitted flow

unit conversion factor = 37,854,120-10^6gal/day

Step 4: Calculate LA and WLA for MS4s. LAs can be calculated under different flow conditions as the water quality target load minus the WLA. The LA is represented by the area under the LDC but above the WLA. The LA at any particular flow exceedance is calculated as shown in the equation below.

LA = TMDL – MOS - ∑WLA

WLA for MS4s. When there are permitted MS4s in the watershed, WLAs for MS4s will be caluculated based on area prorated LA. This WLA for MS4s may not be the total load allocated for permitted MS4s unless the whole MS4 area is located within the study watershed boundary. However, in most case the study watershed intersects only a portion of the permitted MS4 coverage areas.

Step 5: Estimate WLA Load Reduction. The WLA load reduction was not calculated as it was assumed that continuous dischargers (NPDES-permitted WWTPs) are adequately regulated under existing permits to achieve water quality standards at the end-of-pipe and, therefore, no WLA reduction would be required. All SSOs are considered unpermitted discharges under State statute and DEQ regulations. For any MS4s that are located within a watershed requiring a TMDL the load reduction will be equal to the PRG established for the overall watershed.

Step 6: Estimate LA Load Reduction.

After existing loading estimates are computed for each bacterial indicator, nonpoint load reduction estimates for each stream segment are calculated by using the difference between estimated existing loading and the allowable load expressed by the LDC (TMDL-MOS). This difference is expressed as the overall percent reduction goal for the impaired waterbody. For fecal coliform the PRG which ensures that no more than 25 percent of the samples exceed the TMDL based on the instantaneous criteria allocates the loads in a manner that is also protective of the geometric mean criterion. For *E. coli* and Enterococci, because WQ standards are considered to be met if 1) either the geometric mean of all data is less than the geometric mean criteria, or 2) no samples exceed the instantaneous criteria, the TMDL PRG will be the lesser of that required to meet the geometric mean or instantaneous criteria.

SECTION 5
TMDL CALCULATIONS

5.1 Estimated Loading and Critical Conditions

USEPA regulations at 40 CFR 130.7(c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and all applicable water quality standards. To accomplish this, available instream WQM data were evaluated with respect to flows and magnitude of water quality criteria exceedance using LDCs.

To calculate the bacteria load at the WQS, the flow rate at each flow exceedance percentile is multiplied by a unit conversion factor (*24,465,525 ml*s / ft^3*day*) and the criterion specific to each bacterial indicator. This calculation produces the maximum bacteria load in the stream without exceeding the instantaneous standard over the range of flow conditions. The x-axis indicates the flow exceedance percentile, while the y-axis is expressed in terms of a bacteria load.

To estimate existing loading, bacteria observations for the primary body contact recreation season (May 1st through September 30th) from 1999 to 2003 are paired with the flows measured or estimated in that segment on the same date. Pollutant loads are then calculated by multiplying the measured bacteria concentration by the flow rate and a unit conversion factor of *24,465,525 ml*s / ft^3*day*. The associated flow exceedance percentile is then matched with the measured flow from the tables provided in Appendix C. The observed bacteria loads are then added to the LDC plot as points. These points represent individual ambient water quality samples of bacteria. Points above the LDC indicate the bacteria instantaneous standard was exceeded at the time of sampling. Conversely, points under the LDC indicate the sample met the WQS.

The LDC approach recognizes that the assimilative capacity of a waterbody depends on the flow, and that maximum allowable loading varies with flow condition. Existing loading, and load reductions required to meet the TMDL water quality target can also be calculated under different flow conditions. The difference between existing loading and the water quality target is used to calculate the loading reductions required. Percent reduction goals are calculated for each watershed and bacterial indicator species as the reductions in load required in order that no more than 10 percent of the existing instantaneous water quality observations would exceed the water quality target. This is because for the PBCR use to be supported, criteria for each bacterial indicator must be met in each impaired waterbody.

Table 5-1 presents the percent reductions necessary for each bacterial indicator in each of the impaired waterbodies in the Study Area. Attainment of WQS in response to TMDL implementation will be based on results measured in these stream segments. The appropriate PRG for each bacteria indicator for each waterbody in Table 5-1 is denoted by the bold text.

Table 5-1 TMDL Percent Reductions Required to Meet Water Quality Standards for Impaired Waterbodies in the Salt Creek & Sand Creek Study Area

WQM Station	Waterbody ID	Waterbody Name	Percent Reduction Required				
			FC	EC		ENT	
			Instant-aneous	Instant-aneous	Geo-mean	Instant-aneous	Geo-mean
OK621200-04-0010F	OK621200040010_00	Salt Creek				97%	**67%**
OK621200-04-0010J OK621200-04-0010P	OK621200040010_10	Salt Creek				97%	**79%**
OK621200-01-0400C OK621200-01-0400T	OK621200010400_00	Gray Horse Creek	**81%**	84%	**38%**	93%	**76%**
OK621200-02-0020C OK621200-02-0020M	OK621200020020_00	Doga Creek	**61%**	78%	**48%**	87%	**76%**
OK121400-04-0010F OK121400-04-0010T	OK121400040010_00	Sand Creek	**41%**	97%	**12%**	99%	**80%**

LDCs for each impaired waterbody (for the contact recreation season from 1999 through 2007) for each bacteria indicator are shown in Figures 5-1 through 5-14. Observed data during both primary body contact recreation season and secondary body contact recreation season are shown on the load duration curves. However, only data from primary body contact recreation season (May through September) are used to calculate percent reduction goal because this calculated reduction is sufficient to ensure that the secondary body contact recreation criteria are also met.

The LDC for Salt Creek, segment OK621200040010_00 (Figure 5-1) shows Enterococci bacteria measurements at WQM station OK621200-04-0010F. The LDC indicates that Enterococci levels exceed the instantaneous water quality criteria under various flow conditions. This indicates that nonpoint sources are a major cause of impairment and point source discharge may also contribute to the impairment. The exceedance under low flow may be caused by point sources, but also could be caused by failing onsite systems, or direct deposition of animal manure.

The LDCs for Salt Creek, segment OK621200040010_10 (Figure 5-2) show measurements for Enterococci at WQM station OK621200-04-0010J & OK621200-04-0010P. The LDCs indicate that bacteria levels exceed the instantaneous water quality criteria primarily under high flow conditions, but exceedance also occurs under low flows. This indicates that nonpoint sources are a major cause of impairment and point source discharge may also contribute to the impairment. The exceedance under low flow may be caused by point sources, but also could be caused by failing onsite systems, or direct deposition of animal manure.

The LDCs for Gray Horse Creek (Figure 5-3 through 5-5) show measurements for each bacteria indicator at WQM station OK621200-01-0400C & OK621200-01-0400T. The LDCs indicate that bacteria levels exceed the instantaneous water quality criteria under various flow conditions, indicating a combination of point sources and non-point sources as causes for impairments. However, since there is no point source in the watershed, non-point sources must be the cause of the impairments.

The LDCs for Doga Creek (Figure 5-6 through 5-8) show measurements for each bacteria indicator at WQM station OK621200-02-0020C & OK621200-02-0020M. The LDCs indicate that bacteria levels exceed the instantaneous water quality criteria under various flow conditions, indicating a combination of point sources and non-point sources as causes for impairments. However, since there is no point source in the watershed, non-point sources must be the cause of the impairments.

The LDCs for Sand Creek (Figure 5-9 through 5-11) show measurements for each bacteria indicator at WQM station OK121400-04-0010F & OK121400-04-0010T. The LDCs indicate that bacteria levels exceed the instantaneous water quality criteria under various flow conditions, indicating a combination of point sources and non-point sources as causes for impairments. However, since there is no point source in the watershed, non-point sources are left to be the cause of the impairments.

Figure 5-1 Load Duration Curve for Enterococci in Salt Creek (OK621200040010_00)

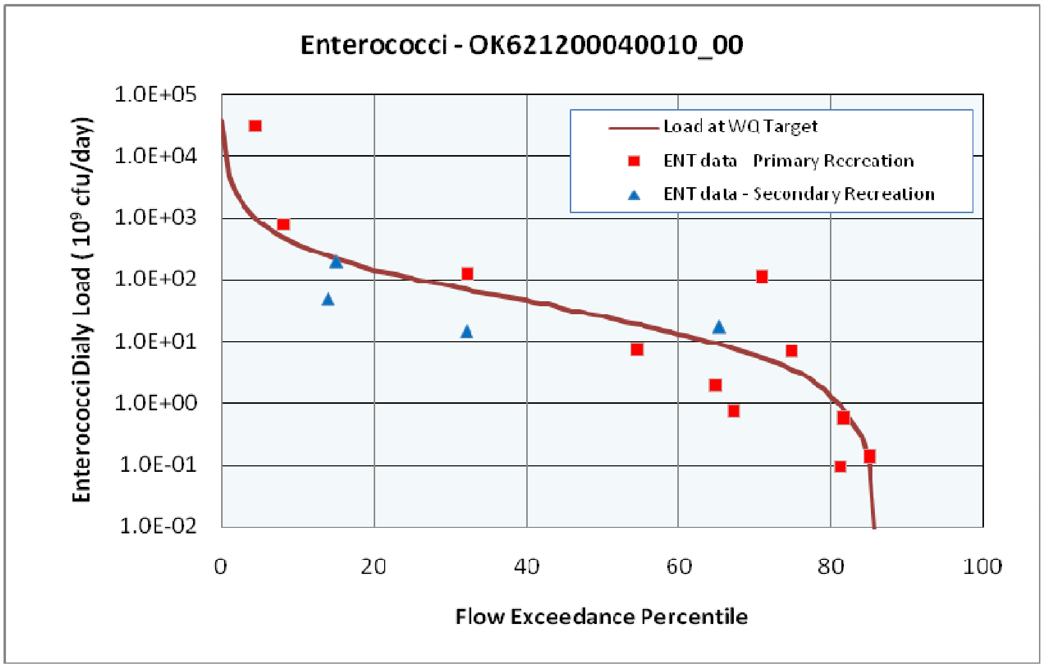


Figure 5-2 Load Duration Curve for Enterococci in Salt Creek (OK621200040010_10)

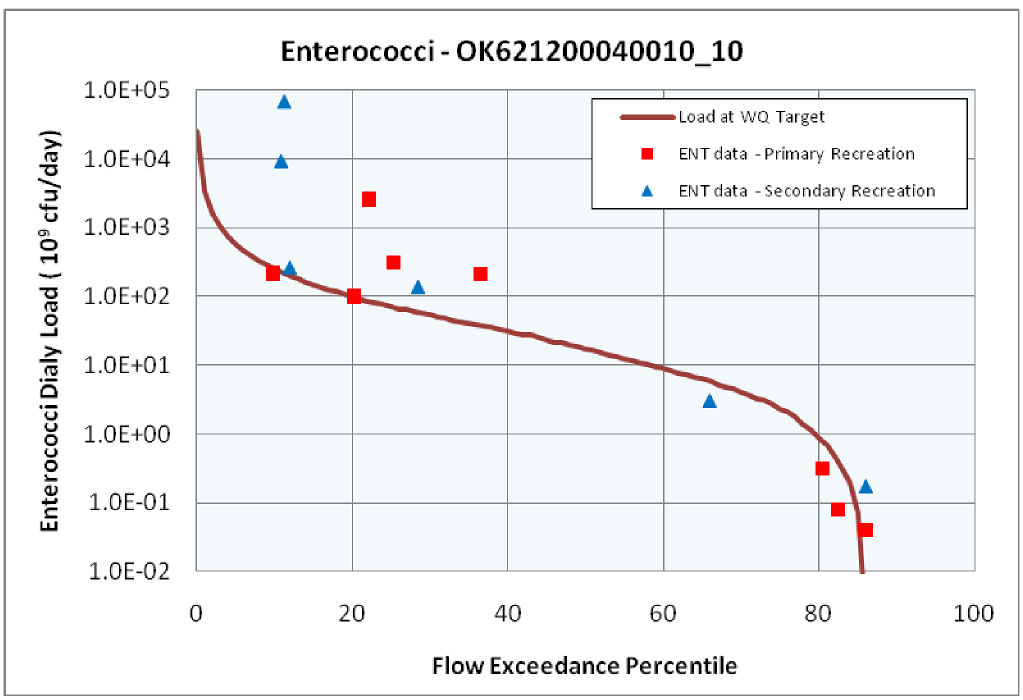


Figure 5-3 Load Duration Curve for Fecal Coliform in Gray Horse Creek (OK621200010400_00)

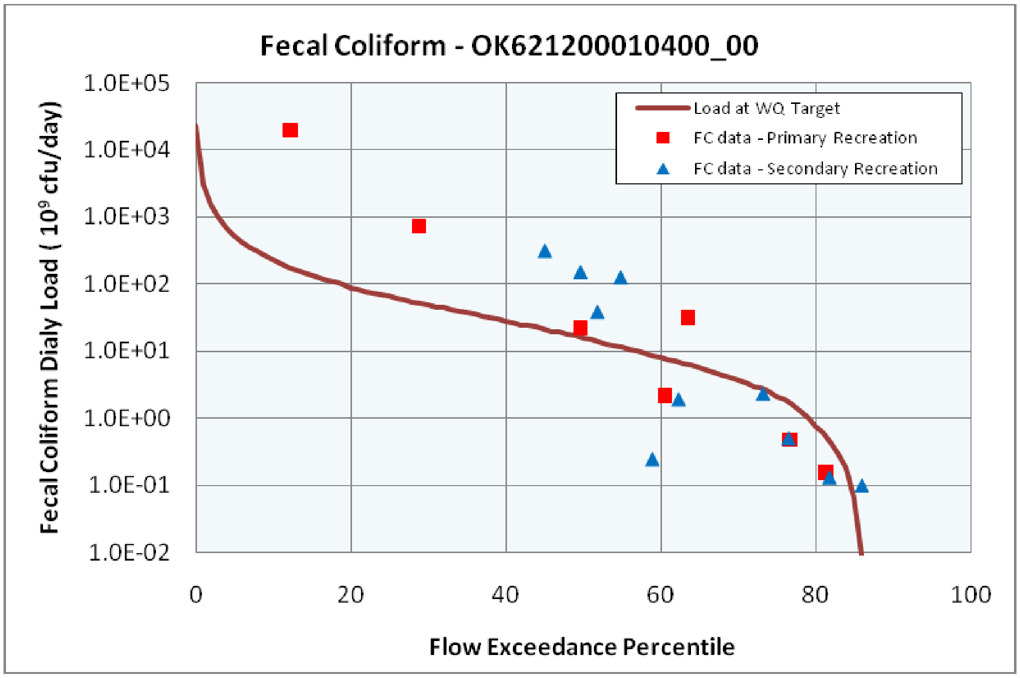


Figure 5-4 Load Duration Curve for Enterococci in Gray Horse Creek (OK621200010400_00)

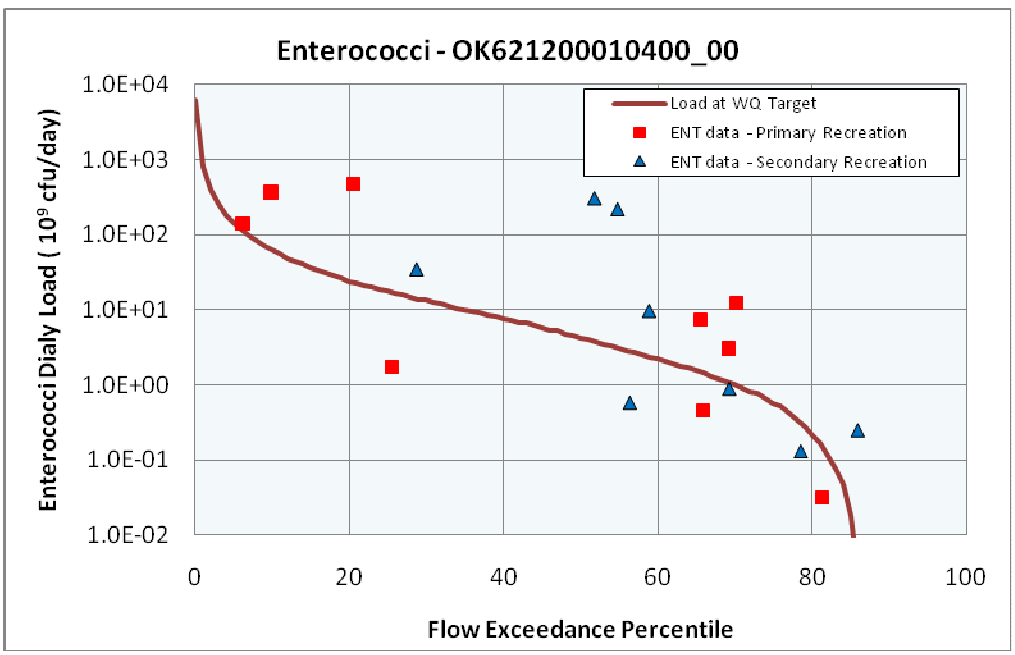


Figure 5-5 Load Duration Curve for E. Coli in Gray Horse Creek (OK621200010400_00)

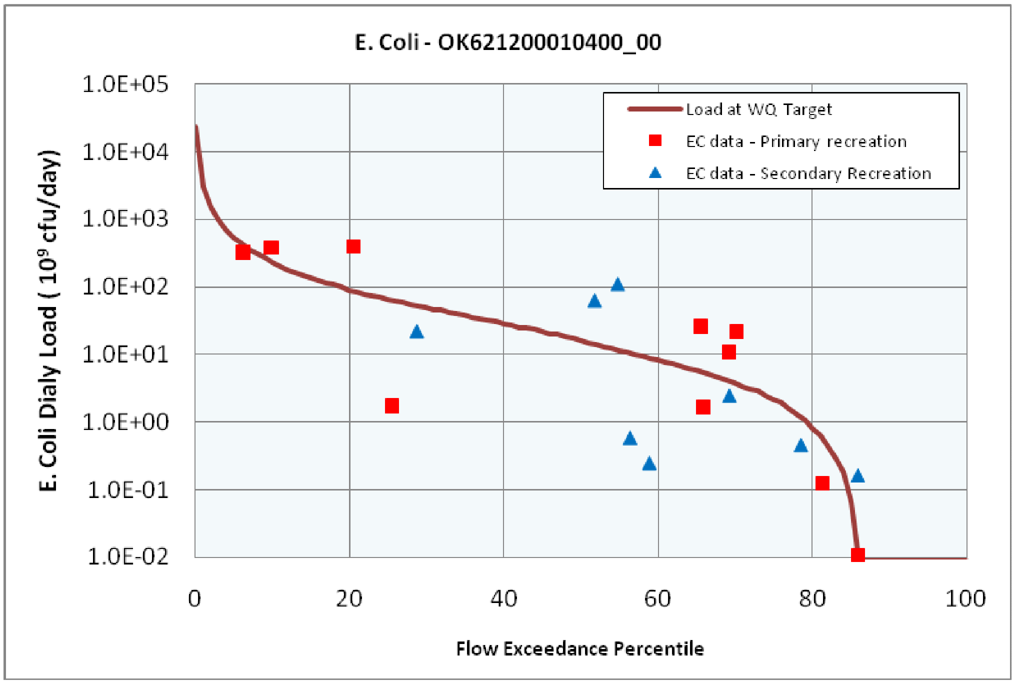


Figure 5-6 Load Duration Curve for Fecal Coliform in Doga Creek (OK621200020020_00)

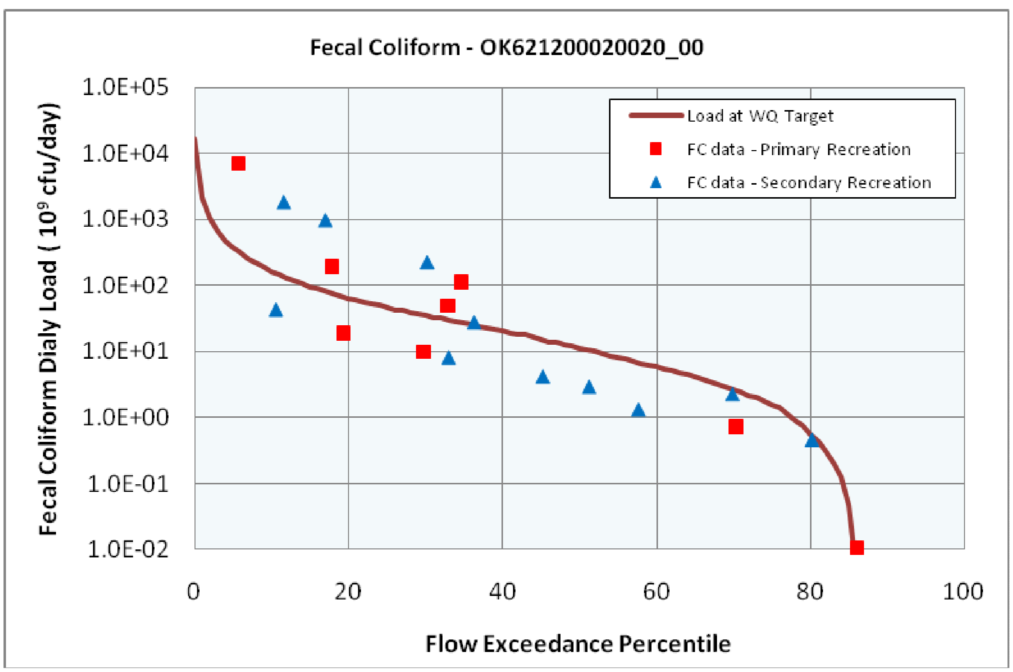


Figure 5-7 Load Duration Curve for Enterococci in Doga Creek (OK621200020020_00)

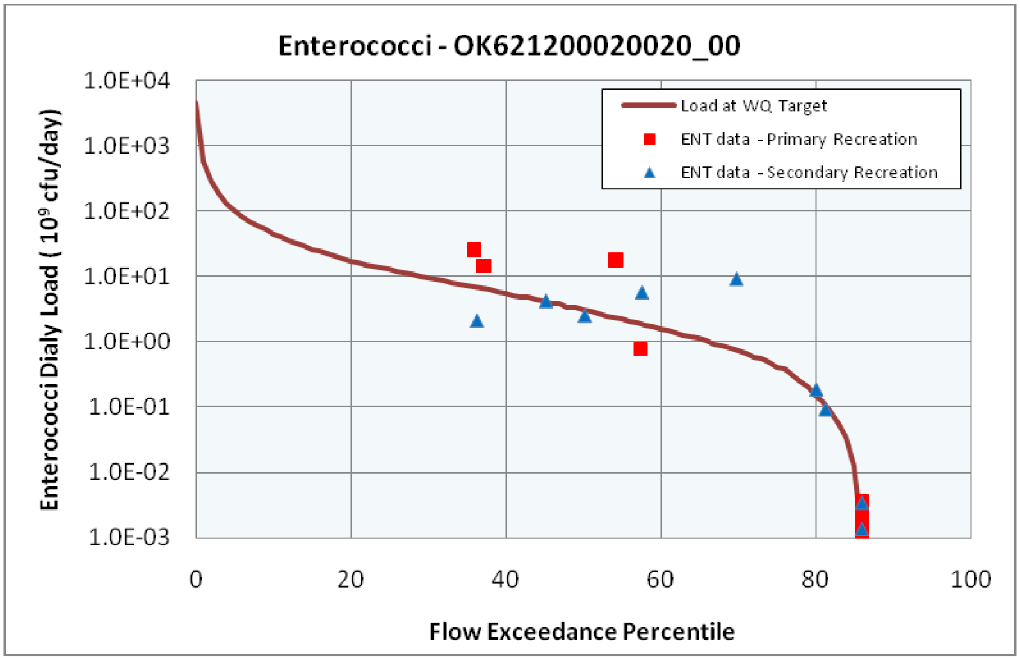


Figure 5-8 Load Duration Curve for E. Coli in Doga Creek (OK621200020020_00)

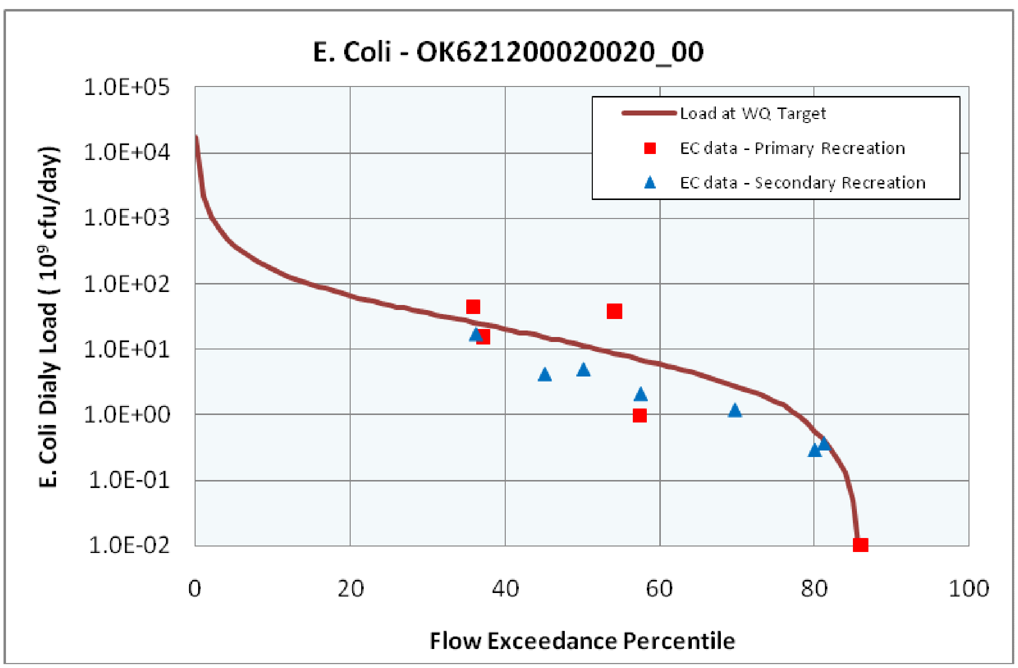


Figure 5-9 Load Duration Curve for Fecal Coliform in Sand Creek (OK121400040010_00)

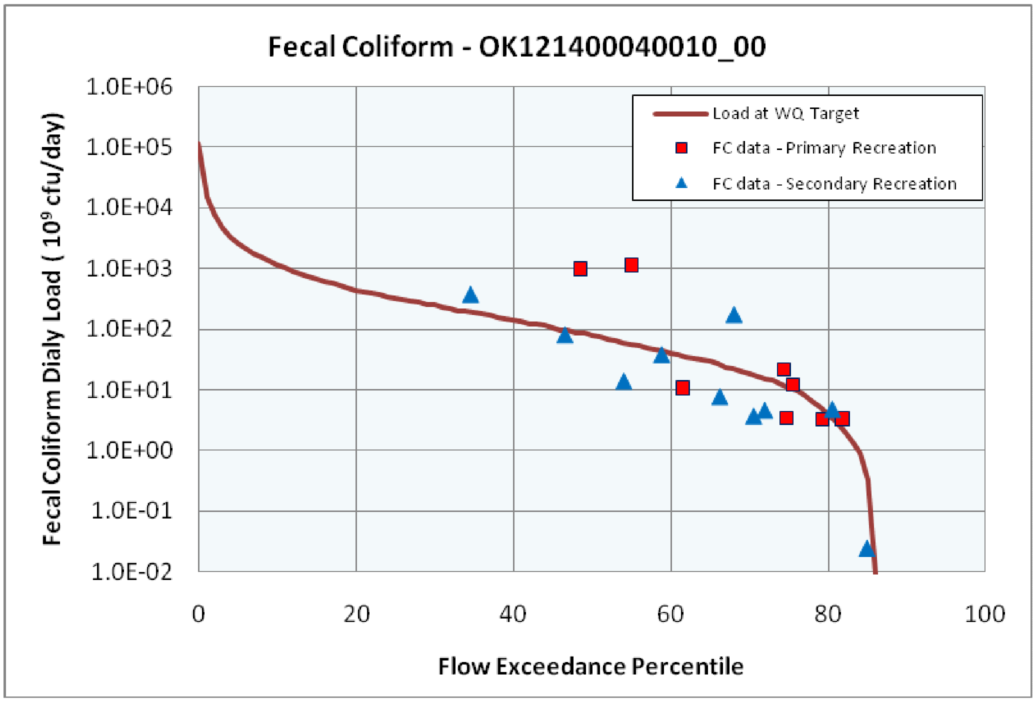


Figure 5-10 Load Duration Curve for Enterococci in Sand Creek (OK121400040010_00)

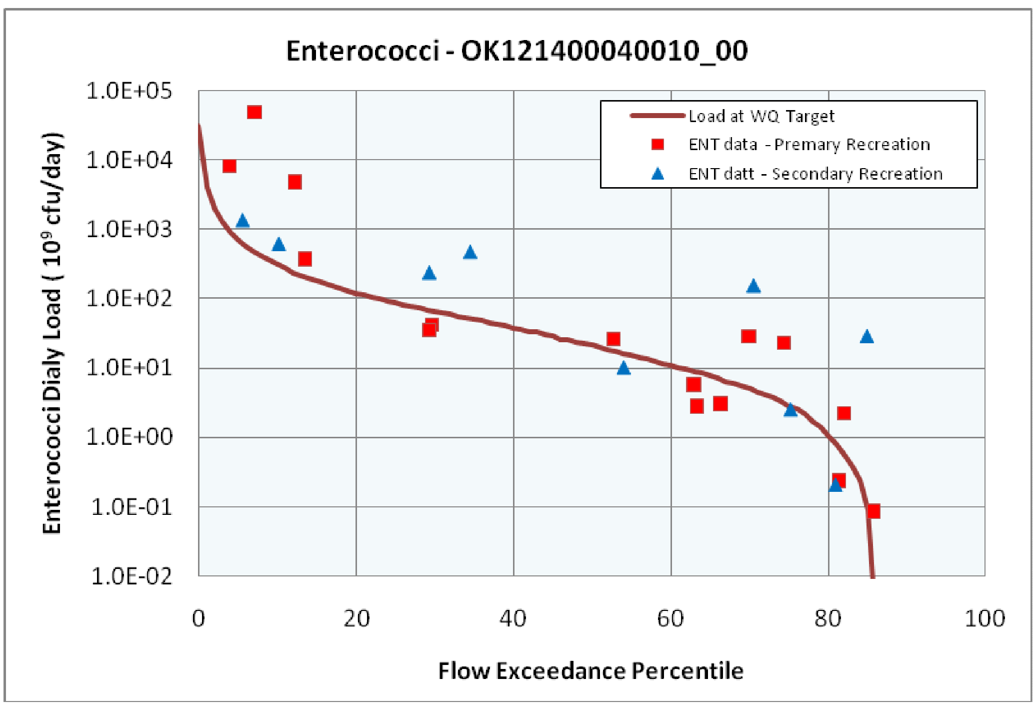
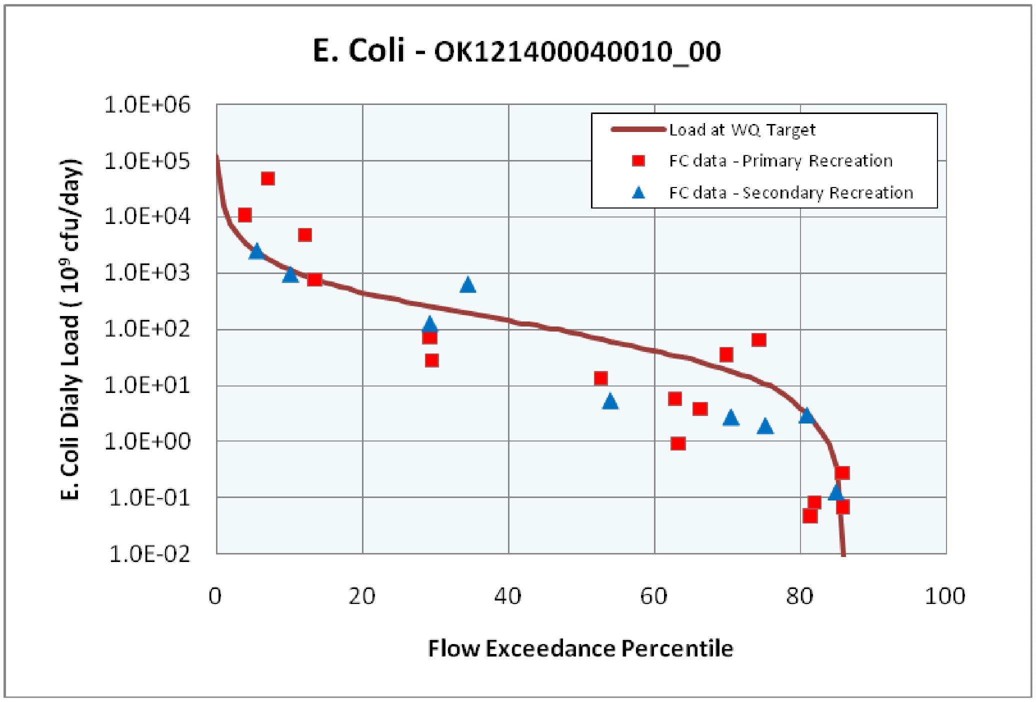


Figure 5-11 Load Duration Curve for E. Coli in Sand Creek (OK121400040010_00)



5.2 Wasteload Allocation

NPDES-permitted facilities are allocated a daily wasteload calculated as their permitted daily average discharge flow rate multiplied by the instream single-sample water quality criterion. In other words, the facilities are required to meet instream criteria in their discharge. Table 5-2 summarizes the WLA of the NPDES-permitted facilities within the study area. The WLA for each facility is derived from the following equation:

*WLA (cfu/day) = WQS * flow * unit conversion factor*

Where:

Where: WQS = 200 cfu /100 ml (Fecal coliform); 126 cfu/100 ml (E. coli); or 33 cfu/100 ml (Enterococci)

flow (10^6 gal/day) = permitted flow

unit conversion factor = 37,854,120-10^6gal/day

When multiple NPDES facilities occur within a watershed, individual WLAs are summed and the total WLA for continuous point sources is included in the TMDL calculation for the corresponding waterbody. When there are no NPDES WWTPs discharging into the contributing watershed of a stream segment, then the WLA is zero. Compliance with the WLA will be achieved by adhering to the fecal coliform limits and disinfection requirements of NPDES permits. Table 5-2 indicates which point source dischargers within Oklahoma currently have a disinfection requirement in their permit. Certain facilities that utilize lagoons for treatment have not been required to provide disinfection since storage time and exposure to ultraviolet radiation from sunlight should reduce bacteria levels. In the future, all point source dischargers which are assigned a wasteload allocation but do not currently have a bacteria limit in their permit will receive a permit limit consistent with the wasteload allocation as their permits are reissued. Regardless of the magnitude of the WLA calculated in these TMDLs, future new discharges of bacteria or increased bacteria load from existing discharges will be considered consistent with the TMDL provided that the NPDES permit requires instream criteria to be met.

Table 5-2 Wasteload Allocations for NPDES-Permitted Facilities

Waterbody ID	NPDES Permit No.	Name	Design Flow (mgd)	Disin-fection	Wasteload Allocation (cfu/day)		
					FC	ENT	E Coli
OK621200040010_10 Salt Creek	OK0022993	City of Shidler	0.12	NO		1.50E+08	
OK621200040010_00 Salt Creek	OK0029017	Fairfax PWA	0.206	NO		2.57E+08	

Permitted storm water discharges are considered point sources. There are no permitted MS4s within the study area; therefore, a specific wasteload allocation is not calculated for MS4s.

5.3 Load Allocation

As discussed in Section 3, nonpoint source bacteria loading to the receiving streams of each waterbody emanate from a number of different sources. The LAs for each stream segment are calculated as the difference between the TMDL, MOS, and WLA, as follows:

$$LA = TMDL - \sum WLA - MOS$$

5.4 Seasonal Variability

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. The TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS which limits the PBCR use to the period of May 1st through September 30th. Seasonal variation was also accounted for in these TMDLs by using more than 5 years of water quality data and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

5.5 Margin of Safety

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs include a MOS. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the uncertainty associated with calculating the allowable pollutant loading to ensure WQSs are attained. USEPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for uncertainty, then the MOS is considered explicit.

For the explicit MOS the water quality target was set at 10 percent lower than the water quality criterion for each pathogen which equates to 360 cfu/100 mL, 365.4 cfu/100 mL, and 97.2/100 mL for fecal coliform, *E. coli*, and Enterococci, respectively. The net effect of the TMDL with MOS is that the allowable pollutant loading of each waterbody is slightly reduced. The use of instream bacteria concentrations to estimate existing loading is another conservative element utilized in these TMDLs that can be recognized as an implicit MOS. This conservative approach to establishing the MOS will ensure that both the 30-day geometric mean and instantaneous bacteria standards can be achieved and maintained.

5.6 TMDL Calculations

The bacteria TMDLs for the 303(d)-listed stream segments covered in this report were derived using LDCs. A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for uncertainty concerning the relationship between effluent limitations and water quality.

This definition can be expressed by the following equation:

$$\boldsymbol{TMDL = \Sigma\ WLA + \Sigma\ LA + MOS}$$

For each stream segment the TMDLs presented in this report are expressed as a percent reduction across the full range of flow conditions. The TMDL, WLA, LA, and MOS will vary with flow condition, and are calculated at every 5th flow interval percentile (Tables 5-4 through 5-14). For illustrative purposes, the TMDL, WLA, LA, and MOS are calculated at the median flow (50% exceedance) for the bacteria indicator which requires the most stringent PRG in each stream segment. The WLA component of each TMDL is the sum of all WLAs within the contributing watershed of each stream segment. The sum of the WLAs can be represented as a single line below the LDC. The LDC and the simple equation of:

$$\textit{Average LA} = \textit{average TMDL} - \textit{MOS} - \sum \textit{WLA}$$

can provide an individual value for the LA in counts per day, which represent the area under the TMDL target line and above the WLA line. There are no permitted MS4s within the study area. Where there are no continuous point sources the WLA is zero.

Table 5-3 TMDL Summary Examples

Waterbody ID	Waterbody Name	Indicator Bacteria Species	TMDL† (cfu/day)	WLA† (cfu/day)	LA† (cfu/day)	MOS† (cfu/day)
OK621200040010_00	Salt Creek	ENT	2.75E+10	2.57E+08	2.45E+10	2.75E+09
OK621200040010_10	Salt Creek	ENT	1.92E+10	1.50E+08	1.71E+10	1.92E+09
OK621200010400_00	Gray Horse Creek	FC	1.74E+10	0	1.57E+10	1.74E+09
OK621200020020_00	Doga Creek	ENT	3.41E+09	0	3.07E+09	3.41E+08
OK121400040010_00	Sand Creek	ENT	2.35E+10	0	2.12E+10	2.35E+09

† Derived for illustrative purposes at the median flow value

Table 5-4 Enterococci TMDL Calculations for Salt Creek (OK621200040010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	15425.80	4.08E+13	2.57E+08	3.67E+13	4.08E+12
5	344.74	9.11E+11	2.57E+08	8.20E+11	9.11E+10
10	151.92	4.01E+11	2.57E+08	3.61E+11	4.01E+10
15	88.82	2.35E+11	2.57E+08	2.11E+11	2.35E+10
20	58.43	1.54E+11	2.57E+08	1.39E+11	1.54E+10
25	43.24	1.14E+11	2.57E+08	1.03E+11	1.14E+10
30	32.72	8.65E+10	2.57E+08	7.76E+10	8.65E+09
35	24.54	6.48E+10	2.57E+08	5.81E+10	6.48E+09
40	18.70	4.94E+10	2.57E+08	4.42E+10	4.94E+09
45	14.02	3.71E+10	2.57E+08	3.31E+10	3.71E+09
50	10.40	2.75E+10	2.57E+08	2.45E+10	2.75E+09
55	7.48	1.98E+10	2.57E+08	1.75E+10	1.98E+09
60	5.38	1.42E+10	2.57E+08	1.25E+10	1.42E+09
65	3.86	1.02E+10	2.57E+08	8.91E+09	1.02E+09
70	2.45	6.48E+09	2.57E+08	5.58E+09	6.48E+08
75	1.40	3.71E+09	2.57E+08	3.08E+09	3.71E+08
80	0.51	1.35E+09	2.57E+08	9.54E+08	1.35E+08
85	0.04	2.83E+08	2.57E+08	0	0
90	0.00	2.57E+08	2.57E+08	0	0
95	0.00	2.57E+08	2.57E+08	0	0
100	0.00	2.57E+08	2.57E+08	0	0

Table 5-5 Enterococci TMDL Calculations for Salt Creek (OK621200040010_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	10787.46	2.85E+13	1.50E+08	2.57E+13	2.85E+12
5	241.08	6.37E+11	1.50E+08	5.73E+11	6.37E+10
10	106.24	2.81E+11	1.50E+08	2.52E+11	2.81E+10
15	62.11	1.64E+11	1.50E+08	1.48E+11	1.64E+10
20	40.86	1.08E+11	1.50E+08	9.70E+10	1.08E+10
25	30.24	7.99E+10	1.50E+08	7.18E+10	7.99E+09
30	22.88	6.05E+10	1.50E+08	5.43E+10	6.05E+09
35	17.16	4.53E+10	1.50E+08	4.07E+10	4.53E+09
40	13.08	3.45E+10	1.50E+08	3.09E+10	3.45E+09
45	9.81	2.59E+10	1.50E+08	2.32E+10	2.59E+09
50	7.27	1.92E+10	1.50E+08	1.71E+10	1.92E+09
55	5.23	1.38E+10	1.50E+08	1.23E+10	1.38E+09
60	3.76	9.93E+09	1.50E+08	8.79E+09	9.93E+08
65	2.70	7.13E+09	1.50E+08	6.26E+09	7.13E+08
70	1.72	4.53E+09	1.50E+08	3.93E+09	4.53E+08
75	0.98	2.59E+09	1.50E+08	2.18E+09	2.59E+08
80	0.36	9.41E+08	1.50E+08	6.97E+08	9.41E+07
85	0.03	1.65E+08	1.50E+08	0	0
90	0.00	1.50E+08	1.50E+08	0	0
95	0.00	1.50E+08	1.50E+08	0	0
100	0.00	1.50E+08	1.50E+08	0	0

Table 5-6 Fecal Coliform TMDL Calculations for Gray Horse Creek (OK621200010400_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	2644.42	2.59E+13	0	2.33E+13	2.59E+12
5	59.10	5.78E+11	0	5.21E+11	5.78E+10
10	26.04	2.55E+11	0	2.29E+11	2.55E+10
15	15.23	1.49E+11	0	1.34E+11	1.49E+10
20	10.02	9.80E+10	0	8.82E+10	9.80E+09
25	7.41	7.25E+10	0	6.53E+10	7.25E+09
30	5.61	5.49E+10	0	4.94E+10	5.49E+09
35	4.21	4.12E+10	0	3.71E+10	4.12E+09
40	3.21	3.14E+10	0	2.82E+10	3.14E+09
45	2.40	2.35E+10	0	2.12E+10	2.35E+09
50	1.78	1.74E+10	0	1.57E+10	1.74E+09
55	1.28	1.25E+10	0	1.13E+10	1.25E+09
60	0.92	9.02E+09	0	8.12E+09	9.02E+08
65	0.66	6.47E+09	0	5.82E+09	6.47E+08
70	0.42	4.12E+09	0	3.71E+09	4.12E+08
75	0.24	2.35E+09	0	2.12E+09	2.35E+08
80	0.09	8.55E+08	0	7.69E+08	8.55E+07
85	0.01	7.25E+07	0	6.53E+07	7.25E+06
90	0.00	0	0	0	0
95	0.00	0	0	0	0
100	0.00	0	0	0	0

Table 5-7 Enterococci TMDL Calculations for Gray Horse Creek (OK621200010400_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	2644.42	6.99E+12	0	6.29E+12	6.99E+11
5	59.10	1.56E+11	0	1.41E+11	1.56E+10
10	26.04	6.88E+10	0	6.19E+10	6.88E+09
15	15.23	4.02E+10	0	3.62E+10	4.02E+09
20	10.02	2.65E+10	0	2.38E+10	2.65E+09
25	7.41	1.96E+10	0	1.76E+10	1.96E+09
30	5.61	1.48E+10	0	1.33E+10	1.48E+09
35	4.21	1.11E+10	0	1.00E+10	1.11E+09
40	3.21	8.47E+09	0	7.62E+09	8.47E+08
45	2.40	6.35E+09	0	5.72E+09	6.35E+08
50	1.78	4.71E+09	0	4.24E+09	4.71E+08
55	1.28	3.39E+09	0	3.05E+09	3.39E+08
60	0.92	2.43E+09	0	2.19E+09	2.43E+08
65	0.66	1.75E+09	0	1.57E+09	1.75E+08
70	0.42	1.11E+09	0	1.00E+09	1.11E+08
75	0.24	6.35E+08	0	5.72E+08	6.35E+07
80	0.09	2.31E+08	0	2.08E+08	2.31E+07
85	0.01	1.96E+07	0	1.76E+07	1.96E+06
90	0.00	0	0	0	0
95	0.00	0	0	0	0
100	0.00	0	0	0	0

Table 5-8 E. Coli TMDL Calculations for Gray Horse Creek (OK621200010400_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	2644.42	2.63E+13	0	2.36E+13	2.63E+12
5	59.10	5.87E+11	0	5.28E+11	5.87E+10
10	26.04	2.59E+11	0	2.33E+11	2.59E+10
15	15.23	1.51E+11	0	1.36E+11	1.51E+10
20	10.02	9.95E+10	0	8.95E+10	9.95E+09
25	7.41	7.36E+10	0	6.63E+10	7.36E+09
30	5.61	5.57E+10	0	5.01E+10	5.57E+09
35	4.21	4.18E+10	0	3.76E+10	4.18E+09
40	3.21	3.18E+10	0	2.87E+10	3.18E+09
45	2.40	2.39E+10	0	2.15E+10	2.39E+09
50	1.78	1.77E+10	0	1.59E+10	1.77E+09
55	1.28	1.27E+10	0	1.15E+10	1.27E+09
60	0.92	9.15E+09	0	8.24E+09	9.15E+08
65	0.66	6.57E+09	0	5.91E+09	6.57E+08
70	0.42	4.18E+09	0	3.76E+09	4.18E+08
75	0.24	2.39E+09	0	2.15E+09	2.39E+08
80	0.09	8.68E+08	0	7.81E+08	8.68E+07
85	0.01	7.36E+07	0	6.63E+07	7.36E+06
90	0.00	0	0	0	0
95	0.00	0	0	0	0
100	0.00	0	0	0	0

Table 5-9 Fecal Coliform TMDL Calculations for Doga Creek (OK621200020020_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	1913.08	1.87E+13	0	1.68E+13	1.87E+12
5	42.75	4.18E+11	0	3.77E+11	4.18E+10
10	18.84	1.84E+11	0	1.66E+11	1.84E+10
15	11.01	1.08E+11	0	9.70E+10	1.08E+10
20	7.25	7.09E+10	0	6.38E+10	7.09E+09
25	5.36	5.25E+10	0	4.72E+10	5.25E+09
30	4.06	3.97E+10	0	3.57E+10	3.97E+09
35	3.04	2.98E+10	0	2.68E+10	2.98E+09
40	2.32	2.27E+10	0	2.04E+10	2.27E+09
45	1.74	1.70E+10	0	1.53E+10	1.70E+09
50	1.29	1.26E+10	0	1.14E+10	1.26E+09
55	0.93	9.08E+09	0	8.17E+09	9.08E+08
60	0.67	6.52E+09	0	5.87E+09	6.52E+08
65	0.48	4.68E+09	0	4.21E+09	4.68E+08
70	0.30	2.98E+09	0	2.68E+09	2.98E+08
75	0.17	1.70E+09	0	1.53E+09	1.70E+08
80	0.06	6.18E+08	0	5.57E+08	6.18E+07
85	0.01	5.25E+07	0	4.72E+07	5.25E+06
90	0.00	0	0	0	0
95	0.00	0	0	0	0
100	0.00	0	0	0	0

Table 5-10 Enterococci TMDL Calculations for Doga Creek (OK621200020020_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	1913.08	5.05E+12	0	4.55E+12	5.05E+11
5	42.75	1.13E+11	0	1.02E+11	1.13E+10
10	18.84	4.98E+10	0	4.48E+10	4.98E+09
15	11.01	2.91E+10	0	2.62E+10	2.91E+09
20	7.25	1.91E+10	0	1.72E+10	1.91E+09
25	5.36	1.42E+10	0	1.28E+10	1.42E+09
30	4.06	1.07E+10	0	9.65E+09	1.07E+09
35	3.04	8.04E+09	0	7.24E+09	8.04E+08
40	2.32	6.13E+09	0	5.51E+09	6.13E+08
45	1.74	4.60E+09	0	4.14E+09	4.60E+08
50	1.29	3.41E+09	0	3.07E+09	3.41E+08
55	0.93	2.45E+09	0	2.21E+09	2.45E+08
60	0.67	1.76E+09	0	1.59E+09	1.76E+08
65	0.48	1.26E+09	0	1.14E+09	1.26E+08
70	0.30	8.04E+08	0	7.24E+08	8.04E+07
75	0.17	4.60E+08	0	4.14E+08	4.60E+07
80	0.06	1.67E+08	0	1.50E+08	1.67E+07
85	0.01	1.42E+07	0	1.28E+07	1.42E+06
90	0.00	0	0	0	0
95	0.00	0	0	0	0
100	0.00	0	0	0	0

Table 5-11 E. Coli TMDL Calculations for Doga Creek (OK621200020020_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	1913.08	1.90E+13	0	1.71E+13	1.90E+12
5	42.75	4.25E+11	0	3.82E+11	4.25E+10
10	18.84	1.87E+11	0	1.68E+11	1.87E+10
15	11.01	1.09E+11	0	9.85E+10	1.09E+10
20	7.25	7.20E+10	0	6.48E+10	7.20E+09
25	5.36	5.33E+10	0	4.79E+10	5.33E+09
30	4.06	4.03E+10	0	3.63E+10	4.03E+09
35	3.04	3.02E+10	0	2.72E+10	3.02E+09
40	2.32	2.30E+10	0	2.07E+10	2.30E+09
45	1.74	1.73E+10	0	1.55E+10	1.73E+09
50	1.29	1.28E+10	0	1.15E+10	1.28E+09
55	0.93	9.21E+09	0	8.29E+09	9.21E+08
60	0.67	6.62E+09	0	5.96E+09	6.62E+08
65	0.48	4.75E+09	0	4.28E+09	4.75E+08
70	0.30	3.02E+09	0	2.72E+09	3.02E+08
75	0.17	1.73E+09	0	1.55E+09	1.73E+08
80	0.06	6.28E+08	0	5.65E+08	6.28E+07
85	0.01	5.33E+07	0	4.79E+07	5.33E+06
90	0.00	0	0	0	0
95	0.00	0	0	0	0
100	0.00	0	0	0	0

Table 5-12 Fecal Coliform TMDL Calculations for Sand Creek (OK121400040010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	13200.00	1.29E+14	0	1.16E+14	1.29E+13
5	295.00	2.89E+12	0	2.60E+12	2.89E+11
10	130.00	1.27E+12	0	1.14E+12	1.27E+11
15	76.00	7.44E+11	0	6.69E+11	7.44E+10
20	50.00	4.89E+11	0	4.40E+11	4.89E+10
25	37.00	3.62E+11	0	3.26E+11	3.62E+10
30	28.00	2.74E+11	0	2.47E+11	2.74E+10
35	21.00	2.06E+11	0	1.85E+11	2.06E+10
40	16.00	1.57E+11	0	1.41E+11	1.57E+10
45	12.00	1.17E+11	0	1.06E+11	1.17E+10
50	8.90	8.71E+10	0	7.84E+10	8.71E+09
55	6.40	6.26E+10	0	5.64E+10	6.26E+09
60	4.60	4.50E+10	0	4.05E+10	4.50E+09
65	3.30	3.23E+10	0	2.91E+10	3.23E+09
70	2.10	2.06E+10	0	1.85E+10	2.06E+09
75	1.20	1.17E+10	0	1.06E+10	1.17E+09
80	0.44	4.27E+09	0	3.84E+09	4.27E+08
85	0.04	3.62E+08	0	3.26E+08	3.62E+07
90	0.00	0	0	0	0
95	0.00	0	0	0	0
100	0.00	0	0	0	0

Table 5-13 E. Coli TMDL Calculations for Sand Creek (OK121400040010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	13200.00	3.49E+13	0	3.14E+13	3.49E+12
5	295.00	7.79E+11	0	7.02E+11	7.79E+10
10	130.00	3.43E+11	0	3.09E+11	3.43E+10
15	76.00	2.01E+11	0	1.81E+11	2.01E+10
20	50.00	1.32E+11	0	1.19E+11	1.32E+10
25	37.00	9.78E+10	0	8.80E+10	9.78E+09
30	28.00	7.40E+10	0	6.66E+10	7.40E+09
35	21.00	5.55E+10	0	4.99E+10	5.55E+09
40	16.00	4.23E+10	0	3.80E+10	4.23E+09
45	12.00	3.17E+10	0	2.85E+10	3.17E+09
50	8.90	2.35E+10	0	2.12E+10	2.35E+09
55	6.40	1.69E+10	0	1.52E+10	1.69E+09
60	4.60	1.22E+10	0	1.09E+10	1.22E+09
65	3.30	8.72E+09	0	7.85E+09	8.72E+08
70	2.10	5.55E+09	0	4.99E+09	5.55E+08
75	1.20	3.17E+09	0	2.85E+09	3.17E+08
80	0.44	1.15E+09	0	1.04E+09	1.15E+08
85	0.04	9.78E+07	0	8.80E+07	9.78E+06
90	0.00	0	0	0	0
95	0.00	0	0	0	0
100	0.00	0	0	0	0

Table 5-14 E. Coli TMDL Calculations for Sand Creek (OK121400040010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	13200.00	1.31E+14	0	1.18E+14	1.31E+13
5	295.00	2.93E+12	0	2.64E+12	2.93E+11
10	130.00	1.29E+12	0	1.16E+12	1.29E+11
15	76.00	7.55E+11	0	6.79E+11	7.55E+10
20	50.00	4.97E+11	0	4.47E+11	4.97E+10
25	37.00	3.68E+11	0	3.31E+11	3.68E+10
30	28.00	2.78E+11	0	2.50E+11	2.78E+10
35	21.00	2.09E+11	0	1.88E+11	2.09E+10
40	16.00	1.59E+11	0	1.43E+11	1.59E+10
45	12.00	1.19E+11	0	1.07E+11	1.19E+10
50	8.90	8.84E+10	0	7.96E+10	8.84E+09
55	6.40	6.36E+10	0	5.72E+10	6.36E+09
60	4.60	4.57E+10	0	4.11E+10	4.57E+09
65	3.30	3.28E+10	0	2.95E+10	3.28E+09
70	2.10	2.09E+10	0	1.88E+10	2.09E+09
75	1.20	1.19E+10	0	1.07E+10	1.19E+09
80	0.44	4.33E+09	0	3.90E+09	4.33E+08
85	0.04	3.68E+08	0	3.31E+08	3.68E+07
90	0.00	0	0	0	0
95	0.00	0	0	0	0
100	0.00	0	0	0	0

5.7 Reasonable Assurances

ODEQ will collaborate with a host of other state agencies and local governments working within the boundaries of state and local regulations to target available funding and technical assistance to support implementation of pollution controls and management measures. Various water quality management programs and funding sources provide reasonable assurance that the pollutant reductions as required by these TMDLs can be achieved and water quality can be restored to maintain designated uses. ODEQ's Continuing Planning Process (CPP), required by the CWA §303(e)(3) and 40 CFR 130.5, summarizes Oklahoma's commitments and programs aimed at restoring and protecting water quality throughout the State (ODEQ 2007). The CPP can be viewed from ODEQ's website at http://www.deq.state.ok.us/WQDnew/pubs/2006_cpp_final.pdf. Table 5-15 provides a partial list of the state partner agencies ODEQ will collaborate with to address point and nonpoint source reduction goals established by TMDLs.

Table 5-15 Partial List of Oklahoma Water Quality Management Agencies

Agency	Web Link
Oklahoma Conservation Commission	http://www.ok.gov/conservation/Agency_Divisions/Water_Quality_Division
Oklahoma Department of Wildlife Conservation	http://www.wildlifedepartment.com
Oklahoma Department of Agriculture, Food, and Forestry	http://www.oda.state.ok.us/aems.htm
Oklahoma Water Resources Board	http://www.owrb.ok.gov/quality/index.php

The Oklahoma Conservation Commission (OCC) is the lead agency for Nonpoint Source Pollution in Oklahoma. The primary mechanisms used for management of nonpoint source pollution are incentive-based programs that support the installation of BMPs and public education and outreach. Other programs include regulations and permits for CAFOs. The CAFO Act, as administered by the ODAFF, provides CAFO operators the necessary tools and information to deal with the manure and wastewater animals produce so streams, lakes, ponds, and groundwater sources are not polluted. In addition, financial incentives are currently available to assist qualified applicants with construction of fences to create riparian buffers, ponds, wells, livestock watering facilities and stream crossings through the USDA, Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Programs (DQIP) and the Wildlife Habitat Incentives Program (WHIP).

As authorized by Section 402 of the CWA, the ODEQ has delegation of the NPDES Program in Oklahoma, except for certain jurisdictional areas related to agriculture and the oil and gas industry retained by State Department of Agriculture and Oklahoma Corporation Commission, for which the USEPA has retained permitting authority. The NPDES Program in Oklahoma is implemented via OAC Title 252, Chapter 606 and the Oklahoma Pollutant Discharge Elimination System (OPDES) Act and in accordance with the agreement between ODEQ and USEPA relating to administration and enforcement of the delegated NPDES

Program. Implementation of point source WLAs is done through permits issued under the OPDES program.

The reduction rates called for in this TMDL report are as high as 81 percent. The ODEQ recognizes that achieving such high reductions may not be realistic, especially since unregulated nonpoint sources are a major cause of the impairment. The high reduction rates are not uncommon for pathogen-impaired waters. Similar reduction rates are often found in other pathogen TMDLs around the nation. The suitability of the current criteria for pathogens and the beneficial uses of the receiving stream should be reviewed. For example, the Kansas Department of Environmental Quality has proposed to exclude certain high flow conditions during which pathogen standards will not apply, although that exclusion was not approved by the USEPA. Additionally, USEPA has been conducting new epidemiology studies and may develop new recommendations for pathogen criteria in the near future.

Revisions to the current pathogen provisions of Oklahoma's WQS should be considered. There are three basic approaches to such revisions that may apply.

- **Removing the PBCR use**: This revision would require documentation in a Use Attainability Analysis that the use is not existing and cannot be attained. It is unlikely this approach would be successful since there is evidence that people do swim in these waterbodies, thus constituting an existing use. Existing uses cannot be removed.
- **Modifying application of the existing criteria**: This approach would include considerations such as an exemption under certain high flow conditions, an allowance for wildlife or "natural conditions," a sub-category of the use or other special provision for urban areas, or other special provisions for storm flows. Since large bacteria violations occur over all flow ranges, it is likely that large reductions would still be necessary. However, this approach may have merit and should be considered.
- **Revising the existing numeric criteria**: Oklahoma's current pathogen criteria are based on USEPA guidelines (See Implementation Guidance for Ambient Water Quality Criteria for Bacteria, May 2002 Draft; and Ambient Water Quality Criteria for Bacteria-1986, January 1986). However, those guidelines have received much criticism and USEPA studies that could result in revisions to their recommendations are ongoing. The use of the three indicators specified in Oklahoma's standards should be evaluated. The numeric criteria values should also be evaluated using a risk-based method such as that found in USEPA guidance.

Unless or until the WQS are revised and approved by USEPA, federal rules require that the TMDLs in this report must be based on attainment of the current standards. If revisions to the pathogen standards are approved in the future, reductions specified in these TMDLs will be re-evaluated.

SECTION 6
PUBLIC PARTICIPATION

This report was submitted to EPA for technical review and accepted on July 10, 2009. A public notice was circulated on July 14, 2009 to local newspapers and/or other publications in the area affected by this TMDL and persons on the DEQ contact list. The public comment period ended on August 28, 2009. No requests for a public meeting were received. One comment from Mr. Quang Pham on behalf of the Oklahoma Department of Agriculture, Food, and Forestry was received. The response to comments is included as Appendix E.

SECTION 7
REFERENCES

American Veterinary Medical Association 2002. U.S. Pet Ownership and Demographics Sourcebook (2002 Edition). Schaumberg, IL.

ASAE (American Society of Agricultural Engineers). 1999. ASAE standards, 46th edition: standards, engineering practices, data. St. Joseph, MI.

Canter, LW and RC Knox 1985. Septic tank system effects on ground water quality. Lewis Publishers, Boca Raton, FL.

Cleland 2003. Cleland, B., TMDL Development from the "Bottom Up" – Part III: Duration Curves and Wet-Weather Assessments. Water Environment Federation National TMDL Science and Policy Conference 2003. Chicago, IL.

Cogger, CG and BL Carlile 1984. Field performance of conventional and alternative septic systems in wet soils. *J. Environ. Qual*. 13 (1).

Drapcho, C.M. and A.K.B. Hubbs 2002. Fecal Coliform Concentration in Runoff from Fields with Applied Dairy Manure. http://www.lwrri.lsu.edu/downloads/Drapcho_annual%20report01-02.pdf

Hall, S. 2002. Washington State Department of Health, Wastewater Management Program Rule Development Committee, Issue Research Report - Failing Systems, June 2002.

Metcalf and Eddy 1991. Wastewater Engineering: Treatment, Disposal, Reuse: 2nd Edition.

ODEQ 2007. The State of Oklahoma 2007 Continuing Planning Process. 2007.

ODEQ 2008. *The State of Oklahoma 2008 Water Quality Assessment Integrated Report*. 2008.

ODEQ 2008a. Oklahoma Department of Environmental Quality. *Individual and Small Public On-site Sewage Treatment Systems* Title 252, Chapter 641. 2008.

Oklahoma Climate Survey. 2005. Viewed August 29, 2005 in

http://climate.ocs.ou.edu/county_climate/Products/County_Climatologies/

OWRB 2006. Oklahoma Water Resources Board. *2006 Water Quality Standards*.

OWRB 2007. Oklahoma Water Resources Board. Viewed June 1, 2007. Implementation of Oklahoma's Water Quality Standards (Chapter 46).

Reed, Stowe &Yanke, LLC 2001. *Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-Site Sewage Facility Systems in Texas*. September 2001.

Schueler, TR. 2000. Microbes and Urban Watersheds: Concentrations, Sources, and Pathways. In *The Practice of Watershed Protection,* TR Schueler and HK Holland, eds. Center for Watershed Protection, Ellicott City, MD.

U.S. Census Bureau 1995. http://www.census.gov/.

U.S. Census Bureau 2000. http://www.census.gov/main/www/cen2000.html

University of Florida 1987. Institute of Food and Agricultural Sciences, University Of Florida, Florida Cooperative Extension Service, No. 31, December, 1987.

USDA 2002, Census of Agriculture, National Agricultural Statistics Service, United States Department of Agriculture. http://www.nass.usda.gov/Census/Create_Census_US_CNTY.jsp

USEPA 1983. Final Report of the Nationwide Urban Runoff Program. U.S. Environmental Protection Agency, Water Planning Division.

USEPA 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Office of Water, USEPA 440/4-91-001.

USEPA 2001. 2001 Protocol for Developing Pathogen TMDLs. First Edition. Office of Water, USEPA 841-R-00-002.

USEPA 2003. Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act, TMDL -01-03 - Diane Regas-- July 21, 2003.

USEPA 2005. U.S. Environmental Protection Agency, Office of Water. Stormwater Phase II Final Rule. EPA833-F-00-002 Fact Sheet 2.0. December 2005.

USGS 2007. Multi-Resolution Land Characteristics Consortium. http://www.mrlc.gov/index.asp

USGS 2007a. USGS Daily Streamflow Data. http://waterdata.usgs.gov/nwis/sw

APPENDIX A
AMBIENT WATER QUALITY BACTERIA DATA – 1999 TO 2007

Appendix A

Ambient Water Quality Bacteria Data – 1999 to 2003

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator	Single Sample Criteria * (#/100ml)
OK621200-04-0010F	Salt Creek: Lower	07/23/02	50	EC	406
OK621200-04-0010F	Salt Creek: Lower	08/27/02	>1600	EC	406
OK621200-04-0010F	Salt Creek: Lower	10/01/02	80	EC	2030
OK621200-04-0010F	Salt Creek: Lower	04/29/03	40	EC	2030
OK621200-04-0010F	Salt Creek: Lower	06/02/03	>3000	EC	406
OK621200-04-0010F	Salt Creek: Lower	07/07/03	<10	EC	406
OK621200-04-0010F	Salt Creek: Lower	08/11/03	<20	EC	406
OK621200-04-0010F	Salt Creek: Lower	09/22/03	130	EC	406
OK621200-04-0010F	Salt Creek: Lower	10/20/03	120	EC	2030
OK621200-04-0010F	Salt Creek: Lower	04/27/04	360	EC	2030
OK621200-04-0010F	Salt Creek: Lower	06/01/04	10	EC	406
OK621200-04-0010F	Salt Creek: Lower	05/30/07	420	EC	406
OK621200-04-0010F	Salt Creek: Lower	06/26/07	1480	EC	406
OK621200-04-0010F	Salt Creek: Lower	07/03/07	380	EC	406
OK621200-04-0010F	Salt Creek: Lower	08/06/07	<10	EC	406
OK621200-04-0010F	Salt Creek: Lower	09/11/07	60	EC	406
OK621200-04-0010F	Salt Creek: Lower	07/23/02	10	ENT	108
OK621200-04-0010F	Salt Creek: Lower	08/27/02	190	ENT	108
OK621200-04-0010F	Salt Creek: Lower	10/01/02	<20	ENT	540
OK621200-04-0010F	Salt Creek: Lower	04/29/03	20	ENT	540
OK621200-04-0010F	Salt Creek: Lower	06/02/03	>3000	ENT	108
OK621200-04-0010F	Salt Creek: Lower	07/07/03	<10	ENT	108
OK621200-04-0010F	Salt Creek: Lower	08/11/03	<20	ENT	108
OK621200-04-0010F	Salt Creek: Lower	09/22/03	70	ENT	108
OK621200-04-0010F	Salt Creek: Lower	10/20/03	90	ENT	540
OK621200-04-0010F	Salt Creek: Lower	04/27/04	180	ENT	540
OK621200-04-0010F	Salt Creek: Lower	06/01/04	40	ENT	108
OK621200-04-0010F	Salt Creek: Lower	05/30/07	180	ENT	108
OK621200-04-0010F	Salt Creek: Lower	06/26/07	>2000	ENT	108
OK621200-04-0010F	Salt Creek: Lower	07/03/07	130	ENT	108
OK621200-04-0010F	Salt Creek: Lower	08/06/07	10	ENT	108
OK621200-04-0010F	Salt Creek: Lower	09/11/07	160	ENT	108
OK621200-04-0010J	Salt Creek	08/14/00	<10	EC	406
OK621200-04-0010J	Salt Creek	09/18/00	20	EC	406

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator	Single Sample Criteria * (#/100ml)
OK621200-04-0010J	Salt Creek	10/23/00	860	EC	2030
OK621200-04-0010J	Salt Creek	11/27/00	50	EC	2030
OK621200-04-0010J	Salt Creek	01/08/01	1259	EC	2030
OK621200-04-0010J	Salt Creek	02/12/01	3076	EC	2030
OK621200-04-0010J	Salt Creek	03/19/01	30	EC	2030
OK621200-04-0010J	Salt Creek	09/18/00	150	ENT	108
OK621200-04-0010J	Salt Creek	10/23/00	7000	ENT	540
OK621200-04-0010J	Salt Creek	11/27/00	50	ENT	540
OK621200-04-0010J	Salt Creek	01/08/01	31000	ENT	540
OK621200-04-0010J	Salt Creek	02/12/01	4000	ENT	540
OK621200-04-0010J	Salt Creek	03/19/01	130	ENT	540
OK621200-04-0010J	Salt Creek	04/19/99	4600	FC	2000
OK621200-04-0010J	Salt Creek	05/17/99	400	FC	400
OK621200-04-0010J	Salt Creek	06/14/99	100	FC	400
OK621200-04-0010J	Salt Creek	07/12/99	300	FC	400
OK621200-04-0010J	Salt Creek	08/16/99	100	FC	400
OK621200-04-0010J	Salt Creek	09/27/99	300	FC	400
OK621200-04-0010J	Salt Creek	11/01/99	2500	FC	2000
OK621200-04-0010J	Salt Creek	12/06/99	8000	FC	2000
OK621200-04-0010J	Salt Creek	01/10/00	<100	FC	2000
OK621200-04-0010J	Salt Creek	02/14/00	<100	FC	2000
OK621200-04-0010J	Salt Creek	03/20/00	1000	FC	2000
OK621200-04-0010J	Salt Creek	05/01/00	7000	FC	400
OK621200-04-0010J	Salt Creek	06/05/00	<100	FC	400
OK621200-04-0010J	Salt Creek	07/10/00	40	FC	400
OK621200-04-0010J	Salt Creek	08/14/00	<10	FC	400
OK621200-04-0010J	Salt Creek	09/18/00	90	FC	400
OK621200-04-0010J	Salt Creek	10/23/00	800	FC	2000
OK621200-04-0010J	Salt Creek	11/27/00	134	FC	2000
OK621200-04-0010J	Salt Creek	01/08/01	800	FC	2000
OK621200-04-0010J	Salt Creek	02/12/01	1900	FC	2000
OK621200-04-0010J	Salt Creek	03/19/01	70	FC	2000
OK621200-04-0010P	Salt Creek: Upper	07/23/02	70	EC	406
OK621200-04-0010P	Salt Creek: Upper	08/27/02	<20	EC	406
OK621200-04-0010P	Salt Creek: Upper	10/01/02	100	EC	2030
OK621200-04-0010P	Salt Creek: Upper	04/28/03	60	EC	2030

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator	Single Sample Criteria * (#/100ml)
OK621200-04-0010P	Salt Creek: Upper	06/02/03	>3000	EC	406
OK621200-04-0010P	Salt Creek: Upper	07/07/03	<10	EC	406
OK621200-04-0010P	Salt Creek: Upper	08/11/03	20	EC	406
OK621200-04-0010P	Salt Creek: Upper	09/22/03	<10	EC	406
OK621200-04-0010P	Salt Creek: Upper	10/20/03	50	EC	2030
OK621200-04-0010P	Salt Creek: Upper	04/26/04	560	EC	2030
OK621200-04-0010P	Salt Creek: Upper	06/01/04	110	EC	406
OK621200-04-0010P	Salt Creek: Upper	05/29/07	1380	EC	406
OK621200-04-0010P	Salt Creek: Upper	06/25/07	320	EC	406
OK621200-04-0010P	Salt Creek: Upper	07/03/07	330	EC	406
OK621200-04-0010P	Salt Creek: Upper	07/30/07	930	EC	406
OK621200-04-0010P	Salt Creek: Upper	09/10/07	500	EC	406
OK621200-04-0010P	Salt Creek: Upper	07/23/02	100	ENT	108
OK621200-04-0010P	Salt Creek: Upper	08/27/02	120	ENT	108
OK621200-04-0010P	Salt Creek: Upper	10/01/02	20	ENT	540
OK621200-04-0070C	Little Chief Creek	08/14/00	20	EC	406
OK621200-04-0070C	Little Chief Creek	09/18/00	<10	EC	406
OK621200-04-0070C	Little Chief Creek	10/23/00	10	EC	2030
OK621200-04-0070C	Little Chief Creek	11/27/00	<10	EC	2030
OK621200-04-0070C	Little Chief Creek	01/08/01	24192	EC	2030
OK621200-04-0070C	Little Chief Creek	02/12/01	3654	EC	2030
OK621200-04-0070C	Little Chief Creek	03/19/01	10	EC	2030
OK621200-04-0070C	Little Chief Creek	09/18/00	<10	ENT	108
OK621200-04-0070C	Little Chief Creek	10/23/00	130	ENT	540
OK621200-04-0070C	Little Chief Creek	11/27/00	<10	ENT	540
OK621200-04-0070C	Little Chief Creek	01/08/01	561000	ENT	540
OK621200-04-0070C	Little Chief Creek	02/12/01	4000	ENT	540
OK621200-04-0070C	Little Chief Creek	03/19/01	80	ENT	540
OK621200-04-0070C	Little Chief Creek	04/19/99	1800	FC	2000
OK621200-04-0070C	Little Chief Creek	05/17/99	6000	FC	400
OK621200-04-0070C	Little Chief Creek	06/14/99	100	FC	400
OK621200-04-0070C	Little Chief Creek	07/12/99	300	FC	400
OK621200-04-0070C	Little Chief Creek	08/16/99	<100	FC	400
OK621200-04-0070C	Little Chief Creek	09/27/99	<100	FC	400
OK621200-04-0070C	Little Chief Creek	11/01/99	1400	FC	2000
OK621200-04-0070C	Little Chief Creek	12/06/99	<100	FC	2000

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator	Single Sample Criteria * (#/100ml)
OK621200-04-0070C	Little Chief Creek	01/10/00	<100	FC	2000
OK621200-04-0070C	Little Chief Creek	02/14/00	<100	FC	2000
OK621200-04-0070C	Little Chief Creek	03/20/00	600	FC	2000
OK621200-04-0070C	Little Chief Creek	05/01/00	5000	FC	400
OK621200-04-0070C	Little Chief Creek	06/05/00	<100	FC	400
OK621200-04-0070C	Little Chief Creek	07/10/00	20	FC	400
OK621200-04-0070C	Little Chief Creek	08/14/00	20	FC	400
OK621200-04-0070C	Little Chief Creek	09/18/00	<10	FC	400
OK621200-04-0070C	Little Chief Creek	10/23/00	1400	FC	2000
OK621200-04-0070C	Little Chief Creek	11/27/00	<10	FC	2000
OK621200-04-0070C	Little Chief Creek	01/08/01	22000	FC	2000
OK621200-04-0070C	Little Chief Creek	02/12/01	8000	FC	2000
OK621200-04-0070C	Little Chief Creek	03/19/01	10	FC	2000
OK621200-01-0400C	Gray Horse Creek	08/06/07	10	ENT	108
OK621200-01-0400C	Gray Horse Creek	09/11/07	>2000	ENT	108
OK621200-01-0400T	Gray Horse Creek	08/14/00	20	E. Coli	400
OK621200-01-0400T	Gray Horse Creek	09/18/00	<10	E. Coli	400
OK621200-01-0400T	Gray Horse Creek	10/23/00	6488	E. Coli	2000
OK621200-01-0400T	Gray Horse Creek	11/27/00	31	E. Coli	2000
OK621200-01-0400T	Gray Horse Creek	01/08/01	1607	E. Coli	2000
OK621200-01-0400T	Gray Horse Creek	02/12/01	3448	E. Coli	2000
OK621200-01-0400T	Gray Horse Creek	03/19/01	<10	E. Coli	2000
OK621200-01-0400T	Gray Horse Creek	09/18/00	<10	ENT	108
OK621200-01-0400T	Gray Horse Creek	10/23/00	10000	ENT	540
OK621200-01-0400T	Gray Horse Creek	11/27/00	<10	ENT	540
OK621200-01-0400T	Gray Horse Creek	01/08/01	8000	ENT	540
OK621200-01-0400T	Gray Horse Creek	02/12/01	7000	ENT	540
OK621200-01-0400T	Gray Horse Creek	03/19/01	400	ENT	540
OK621200-01-0400T	Gray Horse Creek	04/19/99	5400	FC	2000
OK621200-01-0400T	Gray Horse Creek	05/17/99	>40000	FC	400
OK621200-01-0400T	Gray Horse Creek	06/14/99	500	FC	400
OK621200-01-0400T	Gray Horse Creek	07/12/99	100	FC	400
OK621200-01-0400T	Gray Horse Creek	08/16/99	<100	FC	400
OK621200-01-0400T	Gray Horse Creek	09/27/99	1800	FC	400
OK621200-01-0400T	Gray Horse Creek	11/01/99	300	FC	2000
OK621200-01-0400T	Gray Horse Creek	12/06/99	3400	FC	2000

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator	Single Sample Criteria * (#/100ml)
OK621200-01-0400T	Gray Horse Creek	01/10/00	100	FC	2000
OK621200-01-0400T	Gray Horse Creek	02/14/00	<100	FC	2000
OK621200-01-0400T	Gray Horse Creek	03/20/00	100	FC	2000
OK621200-01-0400T	Gray Horse Creek	05/01/00	5000	FC	400
OK621200-01-0400T	Gray Horse Creek	06/05/00	100	FC	400
OK621200-01-0400T	Gray Horse Creek	07/10/00	<100	FC	400
OK621200-01-0400T	Gray Horse Creek	08/14/00	10	FC	400
OK621200-01-0400T	Gray Horse Creek	09/18/00	20	FC	400
OK621200-01-0400T	Gray Horse Creek	10/23/00	4000	FC	2000
OK621200-01-0400T	Gray Horse Creek	11/27/00	<10	FC	2000
OK621200-01-0400T	Gray Horse Creek	01/08/01	1000	FC	2000
OK621200-01-0400T	Gray Horse Creek	02/12/01	4000	FC	2000
OK621200-01-0400T	Gray Horse Creek	03/19/01	<10	FC	2000
OK621200-02-0020C	Doga Creek	07/23/02	260	E. Coli	400
OK621200-02-0020C	Doga Creek	08/27/02	>1600	E. Coli	400
OK621200-02-0020C	Doga Creek	10/01/02	320	E. Coli	2000
OK621200-02-0020C	Doga Creek	04/29/03	80	E. Coli	2000
OK621200-02-0020C	Doga Creek	06/02/03	210	E. Coli	400
OK621200-02-0020C	Doga Creek	07/07/03	50	E. Coli	400
OK621200-02-0020C	Doga Creek	08/11/03	60	E. Coli	400
OK621200-02-0020C	Doga Creek	09/22/03	230	E. Coli	400
OK621200-02-0020C	Doga Creek	10/20/03	160	E. Coli	2000
OK621200-02-0020C	Doga Creek	04/27/04	180	E. Coli	2000
OK621200-02-0020C	Doga Creek	05/30/07	460	E. Coli	400
OK621200-02-0020C	Doga Creek	06/26/07	240	E. Coli	400
OK621200-02-0020C	Doga Creek	08/06/07	<10	E. Coli	400
OK621200-02-0020C	Doga Creek	09/11/07	620	E. Coli	400
OK621200-02-0020C	Doga Creek	07/23/02	130	ENT	108
OK621200-02-0020C	Doga Creek	08/27/02	740	ENT	108
OK621200-02-0020C	Doga Creek	10/01/02	80	ENT	540
OK621200-02-0020C	Doga Creek	04/29/03	280	ENT	540
OK621200-02-0020C	Doga Creek	06/02/03	290	ENT	108
OK621200-02-0020C	Doga Creek	07/07/03	40	ENT	108
OK621200-02-0020C	Doga Creek	08/11/03	<20	ENT	108
OK621200-02-0020C	Doga Creek	09/22/03	220	ENT	108
OK621200-02-0020C	Doga Creek	10/20/03	80	ENT	540

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator	Single Sample Criteria * (#/100ml)
OK621200-02-0020C	Doga Creek	04/27/04	110	ENT	540
OK621200-02-0020C	Doga Creek	05/30/07	100	ENT	108
OK621200-02-0020C	Doga Creek	06/26/07	200	ENT	108
OK621200-02-0020C	Doga Creek	08/06/07	<10	ENT	108
OK621200-02-0020C	Doga Creek	09/11/07	360	ENT	108
OK621200-02-0020M	Doga Creek	08/21/00	341	E. Coli	400
OK621200-02-0020M	Doga Creek	09/25/00	860	E. Coli	400
OK621200-02-0020M	Doga Creek	10/30/00	158	E. Coli	2000
OK621200-02-0020M	Doga Creek	12/04/00	189	E. Coli	2000
OK621200-02-0020M	Doga Creek	01/16/01	110	E. Coli	2000
OK621200-02-0020M	Doga Creek	02/20/01	100	E. Coli	2000
OK621200-02-0020M	Doga Creek	03/27/01	246	E. Coli	2000
OK621200-02-0020M	Doga Creek	09/25/00	260	ENT	108
OK621200-02-0020M	Doga Creek	10/30/00	1200	ENT	540
OK621200-02-0020M	Doga Creek	12/04/00	120	ENT	540
OK621200-02-0020M	Doga Creek	01/16/01	300	ENT	540
OK621200-02-0020M	Doga Creek	02/20/01	100	ENT	540
OK621200-02-0020M	Doga Creek	03/27/01	30	ENT	540
OK621200-02-0020M	Doga Creek	04/19/99	4200	FC	2000
OK621200-02-0020M	Doga Creek	05/17/99	7500	FC	400
OK621200-02-0020M	Doga Creek	06/14/99	900	FC	400
OK621200-02-0020M	Doga Creek	07/12/99	100	FC	400
OK621200-02-0020M	Doga Creek	08/16/99	<100	FC	400
OK621200-02-0020M	Doga Creek	09/27/99	1500	FC	400
OK621200-02-0020M	Doga Creek	11/01/99	2300	FC	2000
OK621200-02-0020M	Doga Creek	12/06/99	4800	FC	2000
OK621200-02-0020M	Doga Creek	01/10/00	100	FC	2000
OK621200-02-0020M	Doga Creek	02/14/00	<100	FC	2000
OK621200-02-0020M	Doga Creek	03/20/00	100	FC	2000
OK621200-02-0020M	Doga Creek	05/08/00	<100	FC	400
OK621200-02-0020M	Doga Creek	06/12/00	600	FC	400
OK621200-02-0020M	Doga Creek	08/21/00	860	FC	400
OK621200-02-0020M	Doga Creek	09/25/00	600	FC	400
OK621200-02-0020M	Doga Creek	10/30/00	300	FC	2000
OK621200-02-0020M	Doga Creek	12/04/00	300	FC	2000
OK621200-02-0020M	Doga Creek	01/16/01	70	FC	2000

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator	Single Sample Criteria * (#/100ml)
OK621200-02-0020M	Doga Creek	02/20/01	100	FC	2000
OK621200-02-0020M	Doga Creek	03/27/01	400	FC	2000
OK121400-04-0010F	Sand Creek	08/14/01	<5	EC	406
OK121400-04-0010F	Sand Creek	09/18/01	1770	EC	406
OK121400-04-0010F	Sand Creek	10/23/01	60	EC	2030
OK121400-04-0010F	Sand Creek	04/23/02	180	EC	2030
OK121400-04-0010F	Sand Creek	05/29/02	1060	EC	406
OK121400-04-0010F	Sand Creek	07/09/02	50	EC	406
OK121400-04-0010F	Sand Creek	08/06/02	60	EC	406
OK121400-04-0010F	Sand Creek	09/10/02	<10	EC	406
OK121400-04-0010F	Sand Creek	10/15/02	280	EC	2030
OK121400-04-0010F	Sand Creek	04/08/03	310	EC	2030
OK121400-04-0010F	Sand Creek	05/13/03	70	EC	406
OK121400-04-0010F	Sand Creek	06/17/03	40	EC	406
OK121400-04-0010F	Sand Creek	06/12/06	640	EC	406
OK121400-04-0010F	Sand Creek	08/07/06	260	EC	406
OK121400-04-0010F	Sand Creek	09/11/06	70	EC	406
OK121400-04-0010F	Sand Creek	04/02/07	390	EC	2030
OK121400-04-0010F	Sand Creek	05/07/07	9900	EC	406
OK121400-04-0010F	Sand Creek	06/11/07	1940	EC	406
OK121400-04-0010F	Sand Creek	07/09/07	100	EC	406
OK121400-04-0010F	Sand Creek	07/16/07	350	EC	406
OK121400-04-0010F	Sand Creek	08/20/07	10	EC	406
OK121400-04-0010F	Sand Creek	08/14/01	25	ENT	108
OK121400-04-0010F	Sand Creek	09/18/01	630	ENT	108
OK121400-04-0010F	Sand Creek	10/23/01	80	ENT	540
OK121400-04-0010F	Sand Creek	04/23/02	340	ENT	540
OK121400-04-0010F	Sand Creek	05/29/02	800	ENT	108
OK121400-04-0010F	Sand Creek	07/09/02	40	ENT	108
OK121400-04-0010F	Sand Creek	08/06/02	60	ENT	108
OK121400-04-0010F	Sand Creek	09/10/02	270	ENT	108
OK121400-04-0010F	Sand Creek	10/15/02	20	ENT	540
OK121400-04-0010F	Sand Creek	04/08/03	200	ENT	540
OK121400-04-0010F	Sand Creek	05/13/03	140	ENT	108
OK121400-04-0010F	Sand Creek	06/17/03	60	ENT	108
OK121400-04-0010F	Sand Creek	06/12/06	510	ENT	108

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator	Single Sample Criteria * (#/100ml)
OK121400-04-0010F	Sand Creek	08/07/06	80	ENT	108
OK121400-04-0010F	Sand Creek	09/11/06	10	ENT	108
OK121400-04-0010F	Sand Creek	04/02/07	210	ENT	540
OK121400-04-0010F	Sand Creek	05/07/07	>10000	ENT	108
OK121400-04-0010F	Sand Creek	06/11/07	1940	ENT	108
OK121400-04-0010F	Sand Creek	07/09/07	50	ENT	108
OK121400-04-0010F	Sand Creek	07/16/07	170	ENT	108
OK121400-04-0010F	Sand Creek	08/20/07	30	ENT	108
OK121400-04-0010F	Sand Creek	09/18/01	>600	FC	400
OK121400-04-0010T	Sand Creek	08/15/00	160	EC	406
OK121400-04-0010T	Sand Creek	09/19/00	10	EC	406
OK121400-04-0010T	Sand Creek	11/28/00	51	EC	2030
OK121400-04-0010T	Sand Creek	01/09/01	52	EC	2030
OK121400-04-0010T	Sand Creek	02/13/01	1198	EC	2030
OK121400-04-0010T	Sand Creek	03/20/01	31	EC	2030
OK121400-04-0010T	Sand Creek	09/19/00	40	ENT	108
OK121400-04-0010T	Sand Creek	10/24/00	11000	ENT	540
OK121400-04-0010T	Sand Creek	11/28/00	12000	ENT	540
OK121400-04-0010T	Sand Creek	01/09/01	3000	ENT	540
OK121400-04-0010T	Sand Creek	02/13/01	900	ENT	540
OK121400-04-0010T	Sand Creek	03/20/01	60	ENT	540
OK121400-04-0010T	Sand Creek	04/20/99	2700	FC	2000
OK121400-04-0010T	Sand Creek	05/18/99	4000	FC	400
OK121400-04-0010T	Sand Creek	06/15/99	<100	FC	400
OK121400-04-0010T	Sand Creek	07/13/99	100	FC	400
OK121400-04-0010T	Sand Creek	08/16/99	<100	FC	400
OK121400-04-0010T	Sand Creek	09/28/99	400	FC	400
OK121400-04-0010T	Sand Creek	11/01/99	400	FC	2000
OK121400-04-0010T	Sand Creek	12/07/99	300	FC	2000
OK121400-04-0010T	Sand Creek	01/10/00	<100	FC	2000
OK121400-04-0010T	Sand Creek	02/14/00	<100	FC	2000
OK121400-04-0010T	Sand Creek	03/20/00	300	FC	2000
OK121400-04-0010T	Sand Creek	05/02/00	7000	FC	400
OK121400-04-0010T	Sand Creek	06/06/00	200	FC	400
OK121400-04-0010T	Sand Creek	07/11/00	390	FC	400
OK121400-04-0010T	Sand Creek	08/15/00	140	FC	400

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator	Single Sample Criteria * (#/100ml)
OK121400-04-0010T	Sand Creek	09/19/00	10	FC	400
OK121400-04-0010T	Sand Creek	10/24/00	11000	FC	2000
OK121400-04-0010T	Sand Creek	11/28/00	<10	FC	2000
OK121400-04-0010T	Sand Creek	01/09/01	70	FC	2000
OK121400-04-0010T	Sand Creek	02/13/01	700	FC	2000
OK121400-04-0010T	Sand Creek	03/20/01	80	FC	2000

EC = E. coli; ENT = enterococci; FC = fecal coliform

* Single sample criterion for secondary contact recreation season is shown for all samples collected between October 1st and April 30th.

APPENDIX B
NPDES PERMIT DISCHARGE MONITORING
REPORT DATA AND SANSITARY SEWER OVERFLOW DATA

ODEQ Summary of Available Reports of Sanitary Sewer Overflows

Facility Name	Date	Facility ID	Location	Amount (gal)	Cause	Type of Source
City of Shidler	7/14/2006	S21205	NORTHSIDE OF ALLEY, 2ND & GYPSY & COSDEN			MANHOLE
City of Shidler	11/22/2006	S21205	131 E. 6TH	200	BLOCKAGE	MANHOLE
City of Shidler	12/21/2006	S21205	2ND & COSDEN E. OF N. OF RESIDENCE 150 N. COSDEN	75	BLOCKAGE	MANHOLE
City of Shidler	4/10/2008	S21205	1 BLOCK NORTH OF HWY 11	UNKNOWN	PUMPS IN LIFTSTATION WENT OUT	LIFT STATION
City of Shidler	1/22/1998	S21205	MANHOLE #5	20/MIN	MANHOLE TO LOW- INFILTRATION	
City of Shidler	3/9/1998	S21205	MH #5			
City of Shidler	7/14/2006	S21205	MANHOLE #5 & #6	50GPM	HEAVY RAIN	
City of Shidler	1/22/1998	S21205	MH'S AT LIFT STATION	100 GPM	RAIN	

APPENDIX C
ESTIMATED FLOW EXCEEDANCE PERCENTILES

Appendix C

Estimated Flow Exceedance Percentiles

WQ Station	OK621200-04-0010F	OK621200-04-0010J OK621200-04-0010P	OK621200-04-0070C	OK621200-01-0400C OK621200-01-0400T	OK621200-02-0020C OK621200-02-0020M	OK121400-04-0010F OK121400-04-0010T
	Salt Creek	**Salt Creek**	**Little Chief Creek**	**Gray Horse Creek**	**Doga Creek**	**Sand Creek**
WBID Segment	OK621200040010_00	OK621200040010_10	OK621200040070_00	OK621200010400_00	OK621200020020_00	OK121400040010_00
USGS Gage Reference	07174600	07174600	07174600	07174600	07174600	07174600
Drainage Area (sq. mile)	292.24	204.37	37.78	49.47	36.49	241.87
NRCS Curve Number	72.42	72.42	70.97	66.33	69.45	64.52
Average Annual Rainfall (inch)	38.74	38.74	39.12	39.24	38.48	40.05
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
0	15425.80	10787.46	2013.75	2644.42	1913.08	13200.00
1	1982.45	1386.35	258.80	339.85	245.86	1696.40
2	979.21	684.77	127.83	167.86	121.44	837.92
3	631.59	441.68	82.45	108.27	78.33	540.46
4	444.08	310.55	57.97	76.13	55.07	380.00
5	344.74	241.08	45.00	59.10	42.75	295.00
6	285.14	199.40	37.22	48.88	35.36	244.00
7	233.72	163.45	30.51	40.07	28.99	200.00
8	201.00	140.56	26.24	34.46	24.93	172.00
9	175.29	122.58	22.88	30.05	21.74	150.00
10	151.92	106.24	19.83	26.04	18.84	130.00
11	134.39	93.98	17.54	23.04	16.67	115.00
12	116.86	81.72	15.26	20.03	14.49	100.00
13	107.51	75.19	14.04	18.43	13.33	92.00
14	98.16	68.65	12.81	16.83	12.17	84.00
15	88.82	62.11	11.59	15.23	11.01	76.00
16	81.80	57.21	10.68	14.02	10.15	70.00
17	75.96	53.12	9.92	13.02	9.42	65.00
18	70.12	49.03	9.15	12.02	8.70	60.00
19	64.27	44.95	8.39	11.02	7.97	55.00

WQ Station	OK621200-04-0010F	OK621200-04-0010J OK621200-04-0010P	OK621200-04-0070C	OK621200-01-0400C OK621200-01-0400T	OK621200-02-0020C OK621200-02-0020M	OK121400-04-0010F OK121400-04-0010T
	Salt Creek	**Salt Creek**	**Little Chief Creek**	**Gray Horse Creek**	**Doga Creek**	**Sand Creek**
WBID Segment	OK621200040010_00	OK621200040010_10	OK621200040070_00	OK621200010400_00	OK621200020020_00	OK121400040010_00
USGS Gage Reference	07174600	07174600	07174600	07174600	07174600	07174600
Drainage Area (sq. mile)	292.24	204.37	37.78	49.47	36.49	241.87
NRCS Curve Number	72.42	72.42	70.97	66.33	69.45	64.52
Average Annual Rainfall (inch)	38.74	38.74	39.12	39.24	38.48	40.05
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
20	58.43	40.86	7.63	10.02	7.25	50.00
21	54.93	38.41	7.17	9.42	6.81	47.00
22	51.42	35.96	6.71	8.81	6.38	44.00
23	49.08	34.32	6.41	8.41	6.09	42.00
24	45.58	31.87	5.95	7.81	5.65	39.00
25	43.24	30.24	5.64	7.41	5.36	37.00
26	39.73	27.79	5.19	6.81	4.93	34.00
27	38.56	26.97	5.03	6.61	4.78	33.00
28	36.23	25.33	4.73	6.21	4.49	31.00
29	33.89	23.70	4.42	5.81	4.20	29.00
30	32.72	22.88	4.27	5.61	4.06	28.00
31	30.38	21.25	3.97	5.21	3.77	26.00
32	29.22	20.43	3.81	5.01	3.62	25.00
33	26.88	18.80	3.51	4.61	3.33	23.00
34	25.71	17.98	3.36	4.41	3.19	22.00
35	24.54	17.16	3.20	4.21	3.04	21.00
36	23.37	16.34	3.05	4.01	2.90	20.00
37	22.20	15.53	2.90	3.81	2.75	19.00
38	21.04	14.71	2.75	3.61	2.61	18.00
39	19.87	13.89	2.59	3.41	2.46	17.00
40	18.70	13.08	2.44	3.21	2.32	16.00
41	17.53	12.26	2.29	3.01	2.17	15.00

WQ Station	OK621200-04-0010F	OK621200-04-0010J OK621200-04-0010P	OK621200-04-0070C	OK621200-01-0400C OK621200-01-0400T	OK621200-02-0020C OK621200-02-0020M	OK121400-04-0010F OK121400-04-0010T
	Salt Creek	**Salt Creek**	**Little Chief Creek**	**Gray Horse Creek**	**Doga Creek**	**Sand Creek**
WBID Segment	OK621200040010_00	OK621200040010_10	OK621200040070_00	OK621200010400_00	OK621200020020_00	OK121400040010_00
USGS Gage Reference	07174600	07174600	07174600	07174600	07174600	07174600
Drainage Area (sq. mile)	292.24	204.37	37.78	49.47	36.49	241.87
NRCS Curve Number	72.42	72.42	70.97	66.33	69.45	64.52
Average Annual Rainfall (inch)	38.74	38.74	39.12	39.24	38.48	40.05
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
42	16.36	11.44	2.14	2.80	2.03	14.00
43	16.36	11.44	2.14	2.80	2.03	14.00
44	15.19	10.62	1.98	2.60	1.88	13.00
45	14.02	9.81	1.83	2.40	1.74	12.00
46	12.85	8.99	1.68	2.20	1.59	11.00
47	12.85	8.99	1.68	2.20	1.59	11.00
48	11.69	8.17	1.53	2.00	1.45	10.00
49	11.22	7.85	1.46	1.92	1.39	9.60
50	10.40	7.27	1.36	1.78	1.29	8.90
51	9.80	6.85	1.28	1.68	1.21	8.38
52	9.12	6.37	1.19	1.56	1.13	7.80
53	8.47	5.92	1.11	1.45	1.05	7.25
54	7.95	5.56	1.04	1.36	0.99	6.80
55	7.48	5.23	0.98	1.28	0.93	6.40
56	7.01	4.90	0.92	1.20	0.87	6.00
57	6.54	4.58	0.85	1.12	0.81	5.60
58	6.08	4.25	0.79	1.04	0.75	5.20
59	5.73	4.00	0.75	0.98	0.71	4.90
60	5.38	3.76	0.70	0.92	0.67	4.60
61	5.03	3.51	0.66	0.86	0.62	4.30
62	4.67	3.27	0.61	0.80	0.58	4.00
63	4.32	3.02	0.56	0.74	0.54	3.70

WQ Station	OK621200-04-0010F	OK621200-04-0010J OK621200-04-0010P	OK621200-04-0070C	OK621200-01-0400C OK621200-01-0400T	OK621200-02-0020C OK621200-02-0020M	OK121400-04-0010F OK121400-04-0010T
	Salt Creek	**Salt Creek**	**Little Chief Creek**	**Gray Horse Creek**	**Doga Creek**	**Sand Creek**
WBID Segment	OK621200040010_00	OK621200040010_10	OK621200040070_00	OK621200010400_00	OK621200020020_00	OK121400040010_00
USGS Gage Reference	07174600	07174600	07174600	07174600	07174600	07174600
Drainage Area (sq. mile)	292.24	204.37	37.78	49.47	36.49	241.87
NRCS Curve Number	72.42	72.42	70.97	66.33	69.45	64.52
Average Annual Rainfall (inch)	38.74	38.74	39.12	39.24	38.48	40.05
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
64	4.09	2.86	0.53	0.70	0.51	3.50
65	3.86	2.70	0.50	0.66	0.48	3.30
66	3.51	2.45	0.46	0.60	0.43	3.00
67	3.16	2.21	0.41	0.54	0.39	2.70
68	2.92	2.04	0.38	0.50	0.36	2.50
69	2.69	1.88	0.35	0.46	0.33	2.30
70	2.45	1.72	0.32	0.42	0.30	2.10
71	2.22	1.55	0.29	0.38	0.28	1.90
72	1.99	1.39	0.26	0.34	0.25	1.70
73	1.87	1.31	0.24	0.32	0.23	1.60
74	1.64	1.14	0.21	0.28	0.20	1.40
75	1.40	0.98	0.18	0.24	0.17	1.20
76	1.29	0.90	0.17	0.22	0.16	1.10
77	1.05	0.74	0.14	0.18	0.13	0.90
78	0.84	0.59	0.11	0.14	0.10	0.72
79	0.69	0.48	0.09	0.12	0.09	0.59
80	0.51	0.36	0.07	0.09	0.06	0.44
81	0.41	0.29	0.05	0.07	0.05	0.35
82	0.28	0.20	0.04	0.05	0.03	0.24
83	0.19	0.13	0.02	0.03	0.02	0.16
84	0.12	0.08	0.02	0.02	0.01	0.10
85	0.04	0.03	0.01	0.01	0.01	0.04

WQ Station	OK621200-04-0010F	OK621200-04-0010J OK621200-04-0010P	OK621200-04-0070C	OK621200-01-0400C OK621200-01-0400T	OK621200-02-0020C OK621200-02-0020M	OK121400-04-0010F OK121400-04-0010T
	Salt Creek	**Salt Creek**	**Little Chief Creek**	**Gray Horse Creek**	**Doga Creek**	**Sand Creek**
WBID Segment	OK621200040010_00	OK621200040010_10	OK621200040070_00	OK621200010400_00	OK621200020020_00	OK121400040010_00
USGS Gage Reference	07174600	07174600	07174600	07174600	07174600	07174600
Drainage Area (sq. mile)	292.24	204.37	37.78	49.47	36.49	241.87
NRCS Curve Number	72.42	72.42	70.97	66.33	69.45	64.52
Average Annual Rainfall (inch)	38.74	38.74	39.12	39.24	38.48	40.05
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
86	0.00	0.00	0.00	0.00	0.00	0.00
87	0.00	0.00	0.00	0.00	0.00	0.00
88	0.00	0.00	0.00	0.00	0.00	0.00
89	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00
91	0.00	0.00	0.00	0.00	0.00	0.00
92	0.00	0.00	0.00	0.00	0.00	0.00
93	0.00	0.00	0.00	0.00	0.00	0.00
94	0.00	0.00	0.00	0.00	0.00	0.00
95	0.00	0.00	0.00	0.00	0.00	0.00
96	0.00	0.00	0.00	0.00	0.00	0.00
97	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00
99	0.00	0.00	0.00	0.00	0.00	0.00
100	0.00	0.00	0.00	0.00	0.00	0.00

† incremental watershed area below other gages

Appendix C
General Methodology for Estimating Stream Flow

Flows duration curve will be developed using existing USGS measured flow where the data exist from a gage on the stream segment of interest, or by estimating flow for stream segments with no corresponding flow record. Flow data to support flow duration curves and load duration curves will be derived for each Oklahoma stream segment in the following priority:

i) In cases where a USGS flow gage occurs on, or within one-half mile upstream or downstream of the Oklahoma stream segment.

   a. If simultaneously-collected flow data matching the water quality sample collection date are available, these flow measurements will be used.

   b. If flow measurements at the coincident gage are missing for some dates on which water quality samples were collected, the gaps in the flow record will be filled, or the record will be extended, by estimating flow based on measured streamflows at a nearby gage. First, the most appropriate nearby stream gage is identified. All flow data are first log-transformed to linearize the data because flow data are highly skewed. Linear regressions are then developed between 1) daily streamflow at the gage to be filled/extended, and 2) streamflow at all gages within 95 miles that have at least 300 daily flow measurements on matching dates. The station with the best flow relationship, as indicated by the highest r-squared value, is selected as the index gage. R-squared indicates the fraction of the variance in flow explained by the regression. The regression is then used to estimate flow at the gage to be filled/extended from flow at the index station. Flows will not be estimated based on regressions with r-squared values less than 0.25, even if that is the best regression. In some cases, it will be necessary to fill/extend flow records from two or more index gages. The flow record will be filled/extended to the extent possible based on the best index gage (highest r-squared value), and remaining gaps will be filled from the next best index gage (second highest r-squared value), and so forth.

   c. Flow duration curves will be based on measured flows only, not on the filled or extended flow time series calculated from other gages using regression.

   d. On a stream impounded by dams to form reservoirs of sufficient size to impact stream flow, only flows measured after the date of the most recent impoundment will be used to develop the flow duration curve. This also applies to reservoirs on major tributaries to the stream.

ii) In the case no coincident flow data are available for a stream segment, but flow gage(s) are present upstream and/or downstream without a major reservoir between, flows will be estimated for the stream segment from an upstream or downstream gage using a watershed area ratio method derived by delineating subwatersheds, and relying on the National Resources Conservation Service (NRCS) runoff curve numbers and antecedent rainfall condition. Drainage subbasins will first be delineated for all impaired 303(d)-listed stream segments, along with all USGS flow stations located in the 8-digit HUCs with impaired streams. Then all the USGS gage stations upstream and downstream of the subwatersheds with 303(d) listed stream segments will be identified.

a. Watershed delineations are performed using ESRI Arc Hydro with a 30 m resolution National Elevation Dataset (NED) digital elevation model, and National Hydrography Dataset (NHD) streams. The area of each watershed will be calculated following watershed delineation.
b. The watershed average curve number is calculated from soil properties and land cover as described in the U.S. Department of Agriculture (USDA) Publication *TR-55: Urban Hydrology for Small Watersheds*. The soil hydrologic group is extracted from NRCS STATSGO soil data, and land use category from the 2001 National Land Cover Dataset (NLCD). Based on land use and the hydrologic soil group, SCS curve numbers are estimated at the 30-meter resolution of the NLCD grid as shown in Table 7. The average curve number is then calculated from all the grid cells within the delineated watershed.
c. The average rainfall is calculated for each watershed from gridded average annual precipitation datasets for the period 1971-2000 (Spatial Climate Analysis Service, Oregon State University, http://www.ocs.oregonstate.edu/prism/, created 20 Feb 2004).

Table C-1 Runoff Curve Numbers for Various Land Use Categories and Hydrologic Soil Groups

NLCD Land Use Category	Curve number for hydrologic soil group			
	A	B	C	D
0 in case of zero	100	100	100	100
11 Open Water	100	100	100	100
12 Perennial Ice/Snow	100	100	100	100
21 Developed, Open Space	39	61	74	80
22 Developed, Low Intensity	57	72	81	86
23 Developed, Medium Intensity	77	85	90	92
24 Developed, High Intensity	89	92	94	95
31 Barren Land (Rock/Sand/Clay)	77	86	91	94
32 Unconsolidated Shore	77	86	91	94
41 Deciduous Forest	37	48	57	63
42 Evergreen Forest	45	58	73	80
43 Mixed Forest	43	65	76	82
51 Dwarf Scrub	40	51	63	70
52 Shrub/Scrub	40	51	63	70
71 Grasslands/Herbaceous	40	51	63	70
72 Sedge/Herbaceous	40	51	63	70
73 Lichens	40	51	63	70
74 Moss	40	51	63	70
81 Pasture/Hay	35	56	70	77
82 Cultivated Crops	64	75	82	85
90-99 Wetlands	100	100	100	100

d. Flow at the ungaged site is calculated from the gaged site. The NRCS runoff curve number equation is:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad (1)$$

where:

Q = runoff (inches)

P = rainfall (inches)

S = potential maximum retention after runoff begins (inches)

I_a = initial abstraction (inches)

If $P < 0.2$, $Q = 0$. Initial abstraction has been found to be empirically related to S by the equation

$$I_a = 0.2*S \qquad (2)$$

Thus, the runoff curve number equation can be rewritten:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (3)$$

S is related to the curve number (CN) by:

$$S = \frac{1000}{CN} - 10 \qquad (4)$$

e. First, S is calculated from the average curve number for the gaged watershed. Next, the daily historic flows at the gage are converted to depth basis (as used in equations 1 and 3) by dividing by its drainage area, then converted to inches. Equation 3 is then solved for daily precipitation depth of the gaged site, P_{gaged}. The daily precipitation depth for the ungaged site is then calculated as the precipitation depth of the gaged site multiplied by the ratio of the long-term average precipitation in the watersheds of the ungaged and gaged sites:

$$P_{ungaged} = P_{gaged}\left(\frac{M_{ungaged}}{M_{gaged}}\right) \qquad (5)$$

where M is the mean annual precipitation of the watershed in inches. The daily precipitation depth for the ungaged watershed, along with the average curve number of the ungaged watershed, are then used to calculate the depth equivalent daily flow Q of the ungaged site. Finally, the volumetric flow rate at the ungaged site is calculated by multiplying by the area of the watershed of the ungaged site and converted to cubic ft..

f. If any flow measurements are available on the stream segment of interest, the projected flows will be compared to the measured flows on each date. If there is poor agreement, projections will be repeated with a simpler approach, using only the watershed area ratio and the gaged site (thereby eliminating the influence of differences in curve number and precipitation between the gaged and ungaged stream watersheds). If this simpler approach provides better agreement with existing data, the projected flows based on the simpler approach will be used.

iii) In the rare case where no coincident flow data are available for a stream segment <u>and</u> no gages are present upstream or downstream, flows will be estimated for the stream segment from a gage on an adjacent watershed of similar size and properties, via the same procedure described above for upstream or downstream gages.

APPENDIX D
STATE OF OKLAHOMA ANTIDEGRADATION POLICY

Appendix D
State of Oklahoma Antidegradation Policy

785:45-3-1. Purpose; Antidegradation policy statement

(a) Waters of the state constitute a valuable resource and shall be protected, maintained and improved for the benefit of all the citizens.

(b) It is the policy of the State of Oklahoma to protect all waters of the state from degradation of water quality, as provided in OAC 785:45-3-2 and Subchapter 13 of OAC 785:46.

785:45-3-2. Applications of antidegradation policy

(a) Application to outstanding resource waters (ORW). Certain waters of the state constitute an outstanding resource or have exceptional recreational and/or ecological significance. These waters include streams designated "Scenic River" or "ORW" in Appendix A of this Chapter, and waters of the State located within watersheds of Scenic Rivers. Additionally, these may include waters located within National and State parks, forests, wilderness areas, wildlife management areas, and wildlife refuges, and waters which contain species listed pursuant to the federal Endangered Species Act as described in 785:45-5-25(c)(2)(A) and 785:46-13-6(c). No degradation of water quality shall be allowed in these waters.

(b) Application to high quality waters (HQW). It is recognized that certain waters of the state possess existing water quality which exceeds those levels necessary to support propagation of fishes, shellfishes, wildlife, and recreation in and on the water. These high quality waters shall be maintained and protected.

(c) Application to beneficial uses. No water quality degradation which will interfere with the attainment or maintenance of an existing or designated beneficial use shall be allowed.

(d) Application to improved waters. As the quality of any waters of the state improve, no degradation of such improved waters shall be allowed.

785:46-13-1. Applicability and scope

(a) The rules in this Subchapter provide a framework for implementing the antidegradation policy stated in OAC 785:45-3-2 for all waters of the state. This policy and framework includes three tiers, or levels, of protection.

(b) The three tiers of protection are as follows:

(1) Tier 1. Attainment or maintenance of an existing or designated beneficial use.

(2) Tier 2. Maintenance or protection of High Quality Waters and Sensitive Public and Private Water Supply waters.

(3) Tier 3. No degradation of water quality allowed in Outstanding Resource Waters.

(c) In addition to the three tiers of protection, this Subchapter provides rules to implement the protection of waters in areas listed in Appendix B of OAC 785:45. Although Appendix B areas are not mentioned in OAC 785:45-3-2, the framework for protection of Appendix B areas is similar to the implementation framework for the antidegradation policy.

(d) In circumstances where more than one beneficial use limitation exists for a waterbody, the most protective limitation shall apply. For example, all antidegradation policy implementation rules applicable to Tier 1 waterbodies shall be applicable also to Tier 2 and Tier 3 waterbodies or areas, and implementation rules applicable to Tier 2 waterbodies shall be applicable also to Tier 3 waterbodies.

(e) Publicly owned treatment works may use design flow, mass loadings or concentration, as appropriate, to calculate compliance with the increased loading requirements of this section if those flows, loadings or concentrations were approved by the Oklahoma Department of Environmental Quality as a portion of Oklahoma's Water Quality Management Plan prior to the application of the ORW, HQW or SWS limitation.

785:46-13-2. Definitions

The following words and terms, when used in this Subchapter, shall have the following meaning, unless the context clearly indicates otherwise:

"Specified pollutants" means

(A) Oxygen demanding substances, measured as Carbonaceous Biochemical Oxygen Demand (CBOD) and/or Biochemical Oxygen Demand (BOD);

(B) Ammonia Nitrogen and/or Total Organic Nitrogen;

(C) Phosphorus;

(D) Total Suspended Solids (TSS); and

(E) Such other substances as may be determined by the Oklahoma Water Resources Board or the permitting authority.

785:46-13-3. Tier 1 protection; attainment or maintenance of an existing or designated beneficial use

(a) General.

(1) Beneficial uses which are existing or designated shall be maintained and protected.

(2) The process of issuing permits for discharges to waters of the state is one of several means employed by governmental agencies and affected persons which are designed to attain or maintain beneficial uses which have been designated for those waters. For example, Subchapters 3, 5, 7, 9 and 11 of this Chapter are rules for the permitting process. As such, the latter Subchapters not only implement numerical and narrative criteria, but also implement Tier 1 of the antidegradation policy.

(b) Thermal pollution. Thermal pollution shall be prohibited in all waters of the state. Temperatures greater than 52 degrees Centigrade shall constitute thermal pollution and shall be prohibited in all waters of the state.

(c) Prohibition against degradation of improved waters. As the quality of any waters of the state improves, no degradation of such improved waters shall be allowed.

785:46-13-4. Tier 2 protection; maintenance and protection of High Quality Waters and Sensitive Water Supplies

(a) General rules for High Quality Waters. New point source discharges of any pollutant after June 11, 1989, and increased load or concentration of any specified pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "HQW". Any discharge of any pollutant to a waterbody designated "HQW" which would, if it occurred, lower existing water quality shall be prohibited. Provided however, new point source discharges or increased load or concentration of any specified pollutant from a discharge existing as of June 11, 1989, may be approved by the permitting authority in circumstances where the discharger demonstrates to the satisfaction of the permitting authority that such new discharge or increased load or concentration would result in maintaining or improving the level of water quality which exceeds that necessary to support recreation and propagation of fishes, shellfishes, and wildlife in the receiving water.

(b) General rules for Sensitive Public and Private Water Supplies. New point source discharges of any pollutant after June 11, 1989, and increased load of any specified pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "SWS". Any discharge of any pollutant to a waterbody designated "SWS" which would, if it occurred, lower existing water quality shall be prohibited. Provided however, new point source discharges or increased load of any specified pollutant from a discharge existing as of June 11, 1989, may be approved by the permitting authority in circumstances where the discharger demonstrates to the satisfaction of the permitting authority that such new discharge or increased load will result in maintaining or improving the water quality in both the direct receiving water, if designated SWS, and any downstream waterbodies designated SWS.

(c) Stormwater discharges. Regardless of subsections (a) and (b) of this Section, point source discharges of stormwater to waterbodies and watersheds designated "HQW" and "SWS" may be approved by the permitting authority.

(d) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds of waterbodies designated "HQW" or "SWS" in Appendix A of OAC 785:45.

785:46-13-5. Tier 3 protection; prohibition against degradation of water quality in outstanding resource waters

(a) General. New point source discharges of any pollutant after June 11, 1989, and increased load of any pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "ORW" and/or "Scenic River", and in any waterbody located within the watershed of any waterbody designated with the limitation "Scenic River". Any discharge of any pollutant to a waterbody designated "ORW" or "Scenic River" which would, if it occurred, lower existing water quality shall be prohibited.

(b) Stormwater discharges. Regardless of 785:46-13-5(a), point source discharges of stormwater from temporary construction activities to waterbodies and watersheds designated "ORW" and/or "Scenic River" may be permitted by the permitting authority. Regardless of 785:46-13-5(a), discharges of stormwater to waterbodies and watersheds designated "ORW" and/or "Scenic River" from point sources existing as of June 25, 1992, whether or not such stormwater discharges were permitted as point sources prior to June 25, 1992, may be permitted by the permitting authority; provided, however, increased load of any pollutant from such stormwater discharge shall be prohibited.

(c) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds of waterbodies designated "ORW" in Appendix A of OAC 785:45, provided, however, that development of conservation plans shall be required in sub-watersheds where discharges or runoff from nonpoint sources are identified as causing or significantly contributing to degradation in a waterbody designated "ORW".

(d) LMFO's. No licensed managed feeding operation (LMFO) established after June 10, 1998 which applies for a new or expanding license from the State Department of Agriculture after March 9, 1998 shall be located...[w]ithin three (3) miles of any designated scenic river area as specified by the Scenic Rivers Act in 82 O.S. Section 1451 and following, or [w]ithin one (1) mile of a waterbody [2:9-210.3(D)] designated in Appendix A of OAC 785:45 as "ORW".

785:46-13-6. Protection for Appendix B areas

(a) General. Appendix B of OAC 785:45 identifies areas in Oklahoma with waters of recreational and/or ecological significance. These areas are divided into Table 1, which includes national and state parks, national forests, wildlife areas, wildlife management areas and wildlife refuges; and Table 2, which includes areas which contain threatened or endangered species listed as such by the federal government pursuant to the federal Endangered Species Act as amended.

(b) Protection for Table 1 areas. New discharges of pollutants after June 11, 1989, or increased loading of pollutants from discharges existing as of June 11, 1989, to waters within the boundaries of areas listed in Table 1 of Appendix B of OAC 785:45 may be approved by the permitting authority under such conditions as ensure that the recreational and ecological significance of these waters will be maintained.

(c) Protection for Table 2 areas. Discharges or other activities associated with those waters within the boundaries listed in Table 2 of Appendix B of OAC 785:45 may be restricted through agreements between appropriate regulatory agencies and the United States Fish and Wildlife Service. Discharges or other activities in such areas shall not substantially disrupt the threatened or endangered species inhabiting the receiving water.

(d) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds located within areas listed in Appendix B of OAC 785:45.

APPENDIX E
RESPONSE TO COMMENTS

BACTERIA TOTAL MAXIMUM DAILY LOADS FOR STREAMS IN SALT CREEK AREA, OKLAHOMA

RESPONSE TO COMMENTS

One comment was received from Mr. Quang Pham on behalf of the Oklahoma Department of Agriculture, Food and Forestry.

1. Since the TMDL covers both Salt Creek and Sand Creek Areas in Osage County. It is suggested that the title of the study be: “Bacteria TMDLs for Streams in Salt Creek and Sand Creek Areas, Osage County, Oklahoma”.

Response: “Salt Creek Area” is an adequate descriptor of the study area. No changes were made as a result of this comment.

2. Table 1-2; Name of County; typo: **Kay** County instead of Key County;

Response: The typographical error was corrected.

3. Page 3-1: under 3.1 NPDES Permitted Facilities, 3rd paragraph: last sentence “CAFOs are recognized…properly managed” should be deleted, as no CAFO exists in the study areas.

Response: A statement was added that that there are no NPDES-permitted CAFOs in the study area.

4. Page 3-14: 3rd paragraph, 5th sentence, lines 6-10: “Because litter….up to 50% frequency” should be deleted, as no Poultry Feeding Operations are located in the study areas, and the estimated number of chicken/turkeys raised in the watersheds, shown on table 3-5, is insignificant.

Response: There is no page 3-14 in the document, however the cited language was found on page 3-13. The referenced text discusses possible bacterial loading under various flow conditions for both poultry litter and cattle manure. The discussion is still relevant even though there are no licensed poultry feeding operations in the study area. No changes were made as a result of this comment.